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NEW YORK, JANUARY, 1889.

THE new dynamite gun-boat, *Vesuvius*, has proved herself a very fast vessel. On a recent trial trip in Delaware Bay she ran a distance of 4½ miles at the rate of somewhat over 21 knots an hour, after making the necessary deduction for tide error, and showed her ability to keep up this rate of speed for a considerable distance. Both the speed and the horse-power developed by the engines on this trial exceeded the requirements of the contract, and there is no doubt that the vessel will be accepted, although a further official trial is to be made. The *Vesuvius* has a pair of triple-expansion engines driving twin screws, and supplied by four cylindrical boilers, which are intended to be worked under forced pressure when the vessel is run at full speed. On the trial mentioned, she developed a total of 3,746 indicated H.P. with her two engines, the piston speed being 873 ft. per minute and the working pressure varying from 144 to 162 lbs. The revolutions of the engines at full speed ran from 260 to 268 per minute.

THE meeting of the American Economic Association, which was to begin in Philadelphia, December 26, promises to be a very interesting one. It is to be noted that a considerable part of the session was to be devoted to railroad questions, the programme including papers and discussions on Railroad Statistics, Railroad Rates, and kindred topics. This is not strange, however, when we consider how large a space the railroad occupies in our modern political and economic system.

Another interesting subject for discussion was road legislation in the various States. It is to be hoped that this will attract general attention, for there is, perhaps, hardly anything more in need of reform than our present system of building and maintaining highway roads.

AN interesting little contest in the matter of speed is now going on between the Pennsylvania and the Baltimore & Ohio railroads. Up to November 18 last the quickest time made between Philadelphia and Washington on regular trains was by the Pennsylvania's fast express, which ran through in 3 hours, 25 minutes. On that date the Baltimore & Ohio changed its schedule and ran two fast trains each way, on which the time was reduced to 3 hours, 15 minutes. A few days thereafter the Pennsylvania also changed its time, reducing it to 3 hours, 10 minutes, but on December 9 the Baltimore & Ohio again cut down the running time, making it this time an even 3 hours. Up to date the Pennsylvania has not followed its rival, but will presumably do so. The distance by the Baltimore & Ohio is 134 miles; by the Pennsylvania it is 137.8 miles; but the four miles' difference is more than made up in time by the ferry transfer across Baltimore Harbor, which is required on the Baltimore & Ohio line.

Under the old time-table the average speed of the Pennsylvania train was 43 miles an hour, without allowing for stops or for any delay in passing through Baltimore. Under the latest time-table, if we deduct the time required for the ferry transfer, the Baltimore & Ohio trains must make an average time of somewhat over 50 miles an hour, which is the fastest time ever scheduled for a regular train in this country. The only stops made by these trains between Philadelphia and Baltimore are at Wilmington and Newark, while between Baltimore and Washington there are no stops at all. From Locust Point, Baltimore, to Washington the run is made in 50 minutes, the distance being 41.8 miles, which is certainly very fast time.

How much further this competition is to be continued we do not know, but it has apparently almost reached its limit. The Baltimore & Ohio has, by the way, called its fast trains the "Flying Yankee" and the "Senatorial Express." The first seems to be appropriate enough, but the second is hardly well chosen, in view of the somewhat slow and deliberate method of proceeding of the exalted body after which the train is named.

AN important engineering work now in progress in New York is the sinking of the tracks of the Harlem Railroad through the Annexed District north of the Harlem River. This is an expensive work, involving some careful engineering, especially as the new line is to be built without interfering with the old or with the almost continuous passage of trains over the old tracks. By it all street grade crossings will be done away with for some four miles, through a thickly settled and continually growing section. The advantage to adjacent property will be considerable, but there will be a still greater advantage to the railroad in the ability to make faster time and in the avoidance of accidents.

In this connection attention might again be called to the fact that a better crossing of the Harlem River than the existing bridge is desirable, and will, in fact, be almost a necessity in a very few years.

CONSIDERABLE progress has been made on the new tracks of the New York, New Haven & Hartford Railroad between New Rochelle and Stamford, and parts of them will be brought into use early in the present month. The new work has been very substantially done, and in many places has amounted to an entire relocation and rebuilding of the road, grades being reduced, curves taken out, and the line generally straightened and improved. Between New Rochelle and the junction with the Harlem Railroad at Woodlawn the road has been almost rebuilt, and the new tracks will be a great improvement on the old line.

Stone ballast has been used, with rails of heavy section, and the new tracks will represent the latest improvement in the construction of road-bed and superstructure.

The New Haven Company, although a very rich and prosperous company—perhaps for that reason—has always been considered very conservative and slow to make improvements, but it is now doing a great deal of work on its line at other points also. On the Shore Line Division much work has been done in preparation for a second track, and many improvements have been made in the way of filling in pile-bridges, cutting down grades and similar work.

With the completion of the Thames River Bridge during the present year, and the consequent doing away with the troublesome ferry transfer at New London, faster time will be possible over this road, and it is likely to become the best rail route between New York and Boston.

THE financial collapse of the Panama Canal Company has come somewhat sooner than was expected. Notwithstanding the great efforts made to urge it, the subscription for the new issue of bonds proved to be a failure, the number taken being less than was required by the terms of issue to make the subscription binding, and the Company has come to the end of its available funds. The interest on one issue of its bonds, which was due on December 15, was not paid, and further defaults will probably follow as other interest payments accrue. The Company has applied to the French Government for aid, but it is not probable that anything will be done in this direction. The amount of the Company's stock and bonds, which are held almost entirely in France, and by small investors, is so great that there is some fear of the failure causing a financial crisis in that country, but it is not likely to affect others in any considerable degree.

The consequences to the work now in progress on the Canal will, of course, be disastrous, and there seems to be no alternative except that of stopping the work and leaving it in the condition in which it at present stands; but in a tropical climate work like that which has been done on the Canal will not remain in a stationary condition, and the half-finished excavations will deteriorate very rapidly, and should the stoppage be permanent, will disappear entirely in a few years.

Already there is talk of the reorganization of the Canal Company, and various plans have been proposed, but it will take some time to work out any definite plan, even should one be possible. The latest intelligence is that the affairs of the Company will be for the present in the hands of a provisional committee representing the creditors and stockholders.

A STRONG movement is at present on foot in favor of the purchase of the Swiss railroads by the State, although Switzerland is the last country in Europe where one would expect to find the State railroad system in favor. The Swiss lines have, in general, been fairly profitable, although from the nature of the country several of them have been very expensive roads to build and to work. The line of largest traffic, which is also the most profitable, is that from Zurich to Luzerne, which last year returned nearly nine per cent. upon the capital invested. Some of the smaller lines have, however, been worked at a loss, but last year the average return of all the Swiss railroads was about three per cent. on the stock. The working of these mountain lines requires unusual care, and it has apparently been exercised. The accident list last year included only two persons killed and 89 injured, more than half of these casualties having resulted from the carelessness of the injured persons themselves. Two new lines of some interest are in progress, an extension of the mountain section of the Brunig Railroad and the new Pilatus road, a mountain line on Mount Pilatus.

THE official returns of the Indian railroads show that at the close of last year there were upon the 14,065 miles then open a total of 3,364 locomotives, 8,825 passenger-train cars, and 61,219 freight cars. The increase of equipment was hardly proportional to that in mileage, but large additions will probably be made during the current year. The number of employés at the close of the year was 225,047, which is somewhat higher proportionally to the mileage of road than is found in this country. It is interesting to note that the proportion of Europeans employed on the Indian railroads is gradually decreasing. At the close of 1887 they formed only 4.34 per cent. of the total, the remaining 95.66 per cent. being natives. Even of this 4.34 per cent. classed as Europeans only about one-half come properly under that designation, the remaining half being of European descent, but born in India. The principal change in natives employed during the last year was in engine-runners, in which class there was an increase of nearly 10 per cent. of the number of natives.

An important question, which has always considerably affected the expenses of the Indian railroads, is that of fuel; this is being gradually solved by the opening and development of the coal-mines of the country, and the locomotive expenses are very largely dependent, as might be expected, upon the proximity of the lines to these mines. Thus, on the East Indian Railway, where the coal used comes principally from the company's mines on various sections of its line, the cost of fuel was only about 80 cents per ton, while on the Great Indian Peninsula Railroad, which uses largely English coal, with some wood, the average cost of coal was $4 per ton and the locomotive expenses were naturally very much higher. The East Indian Railway is worked at about as low a cost as any railroad in the world, and the cheap fuel has had a very important part in permitting a constant reduction of expenses.

THE old project of a ship canal to connect the Volga and the Don rivers, and through them the Caspian and the Black Sea, has been revived, and is to be undertaken by a Russian company in which a number of French capitalists are interested. The actual length of the canal will be 54 miles, and the cost, including some river improvement works, is estimated at $20,000,000. The great drawback which has always been urged against this project is the dangerous and difficult navigation of the Sea of Azof, through which ships must pass to reach the mouth of the Don.

A WRITER in a recent number of the Vienna *Zeitschrift für Eisenbahnen* calls attention to the fact that the railroad system of Europe is practically completed, in the sense that—outside of Turkey—it is no longer possible to build any new main or through lines which will not parallel existing lines, or which are at all likely to pay interest on their cost. This explains the great interest lately shown in several European countries in the building of cheap branch lines and feeders to the main lines, and such

railroads are for the time furnishing an outlet for the capital seeking investment in this direction. This field is comparatively a limited one, however, and will soon be filled, so that the disposition to invest in foreign railroads will probably receive a considerable impulse.

For more than a generation past railroads have been a favorite form of investment in almost all civilized countries. The amount thus absorbed has been enormous, and any check to continued demand will be felt in many ways. Of course the building of railroads is not at an end by any means, but in Europe the stage of completion has been nearly reached, and future additions will be each year a smaller percentage of the existing mileage.

The field for future railroad investments will be in Asia and Africa, where there is plenty of room for railroads, but where their building must depend on colonization, the introduction of European ideas, the growth of commerce and many other considerations, both commercial and political. The opening for capital will be great enough, but will have too much of the element of risk to suit the many who prefer the safety of a home investment.

It may be questioned whether we are not, in this country, approaching the European condition. East of the Mississippi—perhaps of the Missouri—it is hard to find where a new through line could be profitably placed, and in some sections even the building of branches has been overdone. Competition is already excessive, and any present increase would hardly be a benefit to the country. Population, wealth, and production are growing here more rapidly than in Europe, but the railroads have grown faster than all, so that they must, in many cases, wait for the growth of the country up to them before their owners can look for even moderate returns.

LOCOMOTIVE FIRE-BOXES.

IN the design and construction of locomotives there seems to be a tendency toward uniformity and similarity in every other part excepting the fire-boxes. There appears to be some influences at work which lead to very wide differences in the forms and proportions which under very similar conditions are adopted for these. Thus there are engines running with boilers originally built for the narrow (3 ft.) gauge, and which have since been altered to run on the standard gauge without changing the fire-boxes. Their grates are only about 18 in. wide and 6 ft. long, so that the grate surface is about 9 square feet. These engines, it is reported, make steam freely, notwithstanding the small size of their grates. The late Mr. Brooks, when he was on the Erie Railroad, at the time it was changed from a 6-ft. gauge to 4 ft. 8½ in., said that the engines which were altered and which had the fire-boxes narrowed seemed to steam as freely and economically with the narrow as they did with the wide grates.

The other extreme of locomotive practice is the Wootten fire-box and others of similar construction with grates 8 ft. wide and 10 ft. long, with a total of 80 square feet of grate surface, or nearly nine times as great as that of the altered narrow-gauge boilers. It is true that most of these boilers with excessively large grates burn anthracite coal, but bituminous coal is burned in some of the Wootten boilers, as on the Chicago, Burlington & Quincy Railroad, and is said to give excellent results.

If we compare the height of fire-boxes, a similar wide difference in practice will be found. Thus the distance from the top of the grate to the under side of the crown-sheet, on ordinary passenger engines, is about 6 ft. In fire-boxes which are placed on top of the frames the height is about 4 ft., and in some of the Wootten fire-boxes from 2 to 2½ ft. In the Strong locomotives the fire-boxes consist of corrugated tubes of 38½ in. smallest diameter. These comparisons are made with engines of different weights and dimensions, but all of a heavy class, so that there is enough similarity in their capacities to be able to contrast the diversity of practice which exists in the construction of their parts. In view of this one cannot help asking, in the language of the humorist, "Why is this thus?" Which is the best, or which gives the most economical results, the small grate or one nine times as big? Apparently the locomotive superintendents and master mechanics of the country have no satisfactory answer to give. If there was any very material difference in the economy of large grates compared with small ones it seems as though the fact would have made itself obvious in the practical performance of the engines which have large grates. If, on the other hand, engines with small grates burned less coal than those with large ones, it seems inconceivable that the phenomenon should not have made itself obvious in the coal accounts of some roads. That the superiority of large over small grates, or *vice versa*, has not been clearly recognized would seem to lead to the inference that the size of the grate is of little importance. Before accepting this conclusion, though, the fact should be noted that, with the present form of construction of locomotives, if the grates are made large, the fire-boxes must be shallow. The reason for this is that when the fire-box is widened it must be put either above the frames, or if, as in the case of the Wootten boilers, they are made wider than the space between the wheels, they must be put above the wheels, which necessarily reduces the height measured from the top of the grates to the crown-sheet. There are locomotive superintendents—Mr. Lauder, of the Old Colony road, for example—who contend that a shallow fire-box will burn bituminous coal as economically as a deep one will. But all the shallow fire-boxes in use, excepting those in the Strong engine, have also been wide—that is, they have been placed on top of the frames, and thus made the full width of the space between the wheels, or they have been of the Wootten type. Now it may very possibly be found that additional width or length will compensate for lack of depth. Part of the Wootten patent is for the use of a combustion chamber with a wide grate, so as to add to the cubical space inside the fire-box. The cubical contents of a deep, narrow fire-box may be as great as that of a wide, shallow one, and it may be that it is a matter of little consequence whether the space is obtained by increasing the width or the depth.

In a paper read by the late Sir Frederick Siemens before the Iron and Steel Institute, in 1884, and from which we have already made extensive quotations,* that distinguished author said:

> It can be easily shown that when flame is brought into contact with any solid body, it is more or less quenched, according to the substance, size and temperature of the body. A very simple experiment in proof of this, and one which is familiar to most people, is the following: Take any ordinary illuminating-gas flame, such, for instance, as a bat's wing, and place a glass rod or tube into the middle of it; the flame will immediately burn dull, and a large quantity of lamp-black will be deposited

* See JOURNAL of June, 1887, page 244.

on the piece of glass. This action is most marked when the rod is cold, but takes place, though in a less degree, at any temperature, for the reason that the material to be heated is necessarily always at a lower temperature than the flame, also owing to the disturbance in the combustion caused by contact of the solid substance with the flame. . . . . The experiments I have made establish the following most important fact—namely, that a good flame, or, in other words, perfect combustion, can only take place in an open space or in one of sufficiently large size to allow the gases to burn out of contact with solid material.

In explanation of this fact the Author explained that he thought the electrical theory of combustion had the best chance of being the right one. According to it a flame consisted of explosions of lightning very numerous and minute. In accepting this theory it was at once evident why a solid body brought into such a flame would obstruct its action, such solid body having the effect of arresting the motion of the gas by attraction and adhesion.

The writer of the paper which has been quoted from applied these principles to boiler and other furnaces, and effected a saving of as much as 25 per cent. in the fuel consumed.

Now, so far as the contact of the flame with the sides and top of a fire-box is concerned, it will make little difference whether the fire-box is deep and narrow or wide and shallow. Obviously to keep the flame as much as possible out of contact with the sides, ends or top until combustion is complete, the fire-box should be of equal width, length and height. No locomotive fire-boxes are now in use which are both wide and deep—that is, we know of none which are, say, 6 ft. wide, 6 ft. high, and 6 ft. or more long. It may very well be—and Mr. Siemens' experiments sustain such an hypothesis—that if a form of construction for locomotives was practicable which would permit of the use of fire-boxes of proportions such as have been suggested, a higher degree of economy would be attained than is possible with any of the fire-boxes which are now used.

While existing forms of construction impose limitations on either the width or the depth of fire-boxes, there is no practical limitation to the size of the grates when they are placed above the wheels. Notwithstanding this fact, there is very great diversity in the size of the open grates, which are used for burning bituminous coal in the large fire-boxes, of which there are now many examples. As long ago as when D. K. Clark wrote his treatise on Railway Machinery he formulated the principle that the larger the heating surface in a boiler and the smaller the open grate area—provided enough coal could be burned in it—the greater would be the economy of fuel.

As has been pointed out for the application of Sir Frederick Siemens' theory, we must have plenty of width, height and length, and D. K. Clark's principle requires that we should have a small open grate. In the wide fire-boxes which are now used there is plenty of width and length, but what seems to be insufficient depth. In many cases, too, the grates are inordinately large, so that they are worked quite contrary to Clark's principle. The fact should be emphasized that a large fire-box does not necessarily mean a correspondingly large grate. We can have a very large amount of cubical space above the grate, while the open portion of the latter may be contracted by means of dead-plates and other appliances. In fact, the available open grate area is quite under the control of a fireman. By simply piling a thick layer of coal on one part and leaving another part open, he can regulate the supply of air which will pass through the bars, and thus practically increase or diminish the effective area. It therefore seems quite possible that the amount of open grate area is not a matter of much practical importance, provided the fireman understands his duties; but it must be frankly admitted that we are in a very great state of ignorance of the whole subject, and that we do not know what are the most economical forms or proportions of fire-boxes or grates for burning bituminous coal.

NAVAL PROGRESS OF THE UNITED STATES.

THE report of the Secretary of the Navy for 1888 is an exceedingly creditable one. As Mr. Whitney well presents the facts, in March, 1885, the United States had no vessel of war which could have kept the seas for one week as against any first-rate naval power, and was dependent upon English manufacturers for the forging of guns, for armor and for secondary batteries.

The efforts of the Department were in the first instance devoted to the problem of domesticating in this country the industries for the making of armor and forgings for high-powered guns, and the first step in this direction was to discontinue all purchases of armor and gun-steel abroad. The wants of the Department in this direction were allowed to accumulate until contracts could be offered to the competition of domestic manufacturers. This was deemed an experiment at the time, and was accompanied by great individual effort toward enlisting the steel manufacturers in the undertaking, but it resulted successfully, and in June, 1887, contracts were entered into with the Bethlehem Iron Company under which the United States was guaranteed that within a reasonable time this country would have within its borders a plant equal to and probably the superior of any in the world for the production of armor and the forgings for high-powered guns. This plant is now nearly ready for work.

The efforts of the Department in ship construction have been devoted to the building of unarmored vessels for cruising, and the Department is able to report that when the ships in course of construction will have been completed the United States will take fair rank among the nations in the possession of unarmored cruisers.

We cannot at present protect our coast, but we can return blow for blow, for we shall soon be in condition to launch a fleet of large and fast cruisers. Two armored fighting ships of high class have been begun, and progress has been made in providing vessels specially adapted for coast defense, in which the new dynamite gun promises to be a valuable auxiliary.

It is gratifying to be able to report that notwithstanding the large expenditures for the new Navy in the last three years, the reduction in other directions has made the total expenditures of the Department less for these years than for the three years ending with 1884, the ordinary expenses having been reduced over 20 per cent.

In ordnance, as well as in ships, excellent progress has been made, and the Chief of that Bureau reports that 37 of the new high-powered steel guns, ranging from 6 in. to 10 in. in caliber, are practically finished, while 22 others are building, and the forgings for the 12-in. guns will be ready early in the present year. The plant of the Naval Gun Factory at Washington is making satisfactory progress, and will soon be in condition to begin work. The trials of the new guns so far completed have been very satisfac-

tory. Contracts for the smaller guns—the Hotchkiss and other rapid-fire guns—are also being filled.

It may here be noted that the first of the experimental cast-steel guns, about which there has been so much discussion, has not proved successful, the first 6-in. gun of this class, made in Pittsburgh, having failed in the first trial at Annapolis, bursting with a charge of 48 lbs. of powder. The result of this test, although unfavorable, can hardly be regarded as finally settling the question of cast-steel guns, and the trial of the Chester cannon will be looked for with interest. A careful examination into the cause of the failure of the first gun, which is now in progress, may give a satisfactory explanation of this result; but however this examination and the tests of the other gun may result, it will be an advantage to have the question decided.

One of the results noted by the Secretary is that substantial progress has been made toward the substitution of machinery of the latest and most improved types for the old-fashioned engines, which were in use in the Navy but a short time ago. How great the progress is may be shown by the statement in the report that the prevailing type of engine in use four years ago furnished 2½ H.P. per ton of machinery, whereas the triple-expansion engines for the latest cruisers can be worked up to 10 H.P. per ton of machinery. How great the gain is in economy and in space can be appreciated by those who have served on shipboard, and especially on a war-ship, where every foot of space is needed.

Of course there is very much still to be done before our Navy is on a proper footing, but that a beginning has been made, and in the right direction, is by itself alone a gratifying advance.

NEW PUBLICATIONS.

DIE REISE S. M. SCHIFFES "FRUNDSBERG" IM ROTHEN MEERE UND AN DEN KÜSTEN VON VORDERINDIEN UND CEYLON, IN DEN JAHREN 1885–86: BY CAPTAIN JEROLIM VON BENKO. Pola, Austria; issued under the Authority of the Ministry of War.

This is an account of a long eastern cruise made by the Austrian war-ship *Frundsberg* through the Suez Canal, the Red Sea, and the Indian Ocean, prepared from the Journal of the Captain, and issued under the authority of the Ministry of War. It gives an interesting account of the various ports visited, etc., and the conduct of the ship. It is accompanied by a large map, showing the route followed through the entire cruise, and by nine smaller maps, of different ports and localities.

MINERAL RESOURCES OF THE UNITED STATES FOR THE CALENDAR YEAR 1887; DAVID T. DAY, CHIEF OF THE DIVISION OF MINING STATISTICS AND TECHNOLOGY. DEPARTMENT OF THE INTERIOR, UNITED STATES GEOLOGICAL SURVEY, J. W. POWELL, DIRECTOR. Washington; Government Printing Office.

This volume is the fifth of the valuable series on the same subject, which began in 1882, and extends the information contained in the previous volumes to include the calendar year 1887. It contains a great mass of statistics and other information arranged by classes and by States. The work of collecting these statistics and arranging them has been mainly done by the Bureau, under the direction of Professor Day, but this work has been supplemented by papers on various subjects, contributed by experts on the several topics. The paper on the Iron and Steel industry of the United States, for instance, has been written by Mr. James M. Swank, General Manager of the American Iron & Steel Association; that on Copper by C. Kirchhoff, Jr.; that on Coal by Mr. Charles A. Ashburner, and on Petroleum and Natural Gas by Mr. James D. Weeks.

The total estimated value of the mineral products of the United States for the year was in round numbers $542,000,000; metallic products forming about $250,000,000, and other mineral substances $292,000,000. Of the metallic products the most important was iron (including steel), estimated at $122,000,000; silver, about $53,500,000, holding the second place, and gold the third, the production being $33,000,000. Of non-metallic products, the most important, both in quality and value, was coal, which was estimated at $182,500,000; building stone, lime, petroleum, and natural gas following at long intervals. The year 1887 shows a considerable increase in mineral products, even over the prosperous year 1886, and their value is greater than in any previous year in the history of the country.

This volume is more complete than any of its predecessors, as the Bureau has increased the efficiency of its methods for the collection of statistics with experience, and is now served by a large number of assistants and observers at different points. It contains much information that is of value to any one interested in the subject, and is almost indispensable for many purposes.

MODERN HELIOGRAPHIC PROCESSES. A MANUAL OF INSTRUCTION IN THE ART OF REPRODUCING DRAWINGS, ENGRAVINGS, MANUSCRIPT, ETC., BY THE ACTION OF LIGHT, FOR THE USE OF ENGINEERS, ARCHITECTS, DRAFTSMEN, ARTISTS AND SCIENTISTS: BY ERNST LIETZE, M.E. New York; published by the Van Nostrand Company (price, $3).

This book, which is, as the Author says, not intended for professional photographers, but for engineers and draftsmen, is one which has been very much needed. The art of making blue-prints and other heliographic reproductions has grown up within a few years, and by its many advantages—including its superior cheapness and quickness—has almost entirely driven out of use the old, slow method of reproducing drawings by tracings. Most draftsmen know something about the common blue-print, but there are many other and finer processes which are not well known, and which present many advantages in special cases, and it has been almost impossible to find any account of these. Most of what has been written on the subject heretofore has been scattered through the various engineering periodicals, proceedings of societies, etc., and has been, therefore, difficult of access. A book in which the various processes are intelligibly and properly described, their methods analyzed, and their advantages shown, ought to be welcome to the great army of draftsmen, in which we would include all engineers, architects, and others who have occasion to make drawings. It appears to be a complete treatise on the subject, at least in so far that it includes all the different processes which have been put to practical use, including some which ought to be more widely known and used than they have been. It includes also a carefully prepared table of the chemicals used in the formulæ given, with their respective prop-

erties and some cautions as to the best method of handling them. This will be very serviceable, as draftsmen are not usually scientific chemists.

The book is an excellent piece of work, mechanically speaking, being well printed. There are a number of illustrations, and it is also accompanied by 10 specimen heliograms taken by different processes, including silver-prints, blue-prints, prussiate of potash prints, cyanotypes, carbon-and-ink prints, and uranium prints developed in different styles.

ABOUT BOOKS AND PERIODICALS.

AMONG the articles in the JOURNAL OF THE MILITARY SERVICE INSTITUTION for December is one on Military and Naval Manœuvres, by Major William R. Livermore; Compulsory Education in the Army, by Brevet Major-General James B. Fry, and Extracts from Minutes of the U. S. Military Philosophical Society, 1808—the latter giving some interesting historical notes on our earliest military association.

An article of much interest appears in SCRIBNER'S MAGAZINE for January, entitled "Railway Management," by General E. P. Alexander, who has had a wide experience as railroad manager in the South and Southwest, and can write from personal experience. This article contains an interesting account of the mystery of making time-tables, and of many other details of management, and gives an analysis of the organization of a railroad, which is complete in its arrangement. This article is one of the most complete of the SCRIBNER'S Railroad Series in its treatment of this very complex subject, giving probably as good an idea of it as could be done in so short a space as could be afforded it in the limits of a magazine.

A professedly humorous paper is a new departure in railroad journalism, but the GENERAL MANAGER, published in Chicago, has undertaken to fill the vacancy, and starts out with fair prospects of success. It is well printed, and gives in each number three colored cartoons and a variety of smaller cuts and entertaining matter.

The POPULAR SCIENCE MONTHLY for January contains an illustrated article on the Guiding Needle on an Iron Ship, by Lieutenant-Commander T. A. Lyons, describing the means taken to counteract the disturbing influences of masses of iron on the compass on board of iron vessels. The always important subject of House Drainage is discussed in the same number by Dr. John S. Billings, U. S. A., who is a high authority on the subject. Dr. Billings's article follows one on the same subject which was published in the July number of the same magazine, and which then called out much criticism and discussion.

The last number of the PROCEEDINGS OF THE UNITED STATES NAVAL INSTITUTE contains articles on the Necessity and Objects of a Naval War College, by Captain A. T. Mahan; Steel Inspection of Structural and Boiler Material, by Lieutenant-Commander J. G. Eaton; the Tactics of the Gun as Discoverable from Type War Ships, by Lieutenant J. F. Meigs; Naval Administration, by Rear-Admiral Luce; Notes on the Literature of Explosives, by Professor Charles E. Monroe; a Study on Fighting Ships, from the French, and the usual notes on naval matters of interest.

From December 1 the publishing business of the late D. Van Nostrand will be continued by the D. Van Nostrand Company, of which Edward N. Crane is President and William H. Farrington Secretary and Treasurer. The new organization will continue the business of publishing and dealing in scientific books at 23 Murray Street, without change, Mr. Farrington having been long connected with the old firm.

BOOKS RECEIVED.

TRANSACTIONS OF THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND: THIRTY-SECOND SESSION, 1888-89. Glasgow, Scotland; issued by the Institution.

MITTHEILUNGEN AUS DEN GEBIETE DES SEEWESENS: VOLUME XVI, 1888, NOS. I–IX. Pola, Austria; issued by the Imperial Hydrographic Office.

OCCASIONAL PAPERS OF THE INSTITUTION OF CIVIL ENGINEERS. London, England; issued by the Institution. The present issue consists of a paper on the Use and Testing of Open-Hearth Steel for Boiler Making, by the late Hamilton Goodall, with an abstract of the discussion on the paper.

SOME RECOLLECTIONS OF AN OLD PHOTOGRAPHIC CLUB: BY COLEMAN SELLERS, E. D. Reprinted from *Anthony's Photographic Bulletin*.

PREPARING FOR INDICATION: PRACTICAL HINTS, THE RESULT OF TWENTY-THREE YEARS' EXPERIENCE WITH THE STEAM-ENGINE INDICATOR: BY ROBERT GRIMSHAW, M.E. New York; the Practical Publishing Company, 21 Park Row (price, $1).

SECOND ANNUAL REPORT OF THE INTERSTATE COMMERCE COMMISSION: THOMAS M. COOLEY, WILLIAM R. MORRISON, AUGUSTUS SCHOONMAKER, ALDACE F. WALKER, WALTER L. BRAGG, COMMISSIONERS; EDWARD A. MOSELEY, SECRETARY. Washington; Government Printing Office.

REPORT OF THE THIRD ASSISTANT POSTMASTER-GENERAL FOR THE FISCAL YEAR ENDING JUNE 30, 1888. H. R. HARRIS, THIRD ASSISTANT POSTMASTER-GENERAL. Washington; Government Printing Office.

TREASURY DEPARTMENT: ANNUAL REPORT OF THE CHIEF OF THE BUREAU OF STATISTICS ON THE FOREIGN COMMERCE OF THE UNITED STATES FOR THE YEAR ENDING JUNE 30, 1888. Washington; Government Printing Office.

REPORTS FROM THE CONSULS OF THE UNITED STATES TO THE STATE DEPARTMENT. NO. 95, JULY, 1888; NO. 96, AUGUST, 1888. Washington; Government Printing Office.

THE CORNELL UNIVERSITY REGISTER, 1888–89. Ithaca, N. Y.; published by the University.

NOTES ON THE DIFFERENTIAL BRAKE: WRITTEN FOR F. M. DAVIS BY HENRY A. VEZIN, M.E. Denver, Col.; *News* Printing Company.

THE DOW POSITIVE PISTON PUMP: CATALOGUE. Philadelphia; the Kensington Engine Works, Limited, Francis Brothers.

THE VOGELSANG SCREW PROPELLER AND ITS ADVANTAGES OVER ALL KNOWN METHODS OF MARINE PROPULSION: BY ALEXANDER VOGELSANG. Brooklyn, N. Y.; issued by the Vogelsang Screw Propeller Company.

THE KENSINGTON FEED-WATER HEATERS AND PURIFIERS: CATALOGUE. Philadelphia; the Kensington Engine Works, Limited, Francis Brothers.

CATALOGUE OF THE LIBRARY OF THE BROWN & SHARPE MANUFACTURING COMPANY: 1888. Providence, R. I.; printed for the Company.

SCIENTIFIC AND MECHANICAL BOOKS; CATALOGUE. New York; Theodore Audel & Company, 91 Liberty Street.

THE DEVELOPMENT OF THE MILITARY RIFLE.

By Lieutenant Joseph M. Califf, Third U. S. Artillery.

Among the many and wonderful improvements in military arms and material during the last half century, that of the rifle has perhaps been the greatest. In the typical modern weapon, with a caliber about that of a squirrel rifle, and of but little greater weight, it is hard to recognize a lineal descendant of the clumsy arm with which the Spaniard of three centuries ago built up an empire at home and conquered one abroad.

If the soldiers who followed the flag and fought the battles of a hundred years ago with a twelve-pound musket of enormous caliber, could come back and see the weapon we put into the hands of our modern infantryman, and knowing nothing of its capabilities, he would have for it probably the same contempt that the Philistine giant had for the sling and stones of the Israelite champion.

Like most other things, the modern rifle has grown from small beginnings. The first portable fire-arm was, however, in the matter of size alone, a most formidable weapon —from 4 to 8 ft. in length and weighing from 15 to 50 pounds. To fire it required the services of two men—one to support it upon its muzzle-rest, and the other to touch it off—the vent being on top of the barrel. The difficulty of keeping the priming in place led to the first improvement—that of putting the vent on the side with a pan to hold the priming. By the addition of a curved arm, pivoted on the side of the stock, and carrying a bit of slow-match, we have the full-fledged matchlock (1517), which held the field as the principal portable fire-arm for fully a hundred years. It was the first serviceable weapon of this kind that had appeared, but remembering its weight and clumsiness, one cannot wonder that when it came to fighting at close quarters the soldier of that day was very prone to fling away his fire-arm and resort to the more familiar pike and sword. The wheel-lock appeared about the same time, in which the arm with its lighted match gave place to a toothed wheel, which, revolving and impinging against a composition of iron and antimony, produced the sparks for igniting the priming. But this system was complicated and expensive, and was never generally adopted, its use being confined to pistols and short arms for mounted men.

About 1525 the Spaniards reduced the length of barrel of their matchlock, and its weight to about 15 pounds, greatly increasing its efficiency. From them it received its distinctive name, *mousquet*.

In 1630 the flint-lock was introduced, and as thus improved, and with the addition of granulated powder, the weapon of the infantryman remained essentially the same for 200 years; the further improvements being in the substitution of iron for wooden ramrods and the use of rude cartridges.

The English "Brown Bess" musket, which figured in our early French and Indian wars, in the Revolution, and in the Napoleonic wars, weighed 11½ pounds, and had a ¾-in. bore. The French musket of the same date weighed two pounds less. The "Brown Bess" held the field until 1839, when it gave place to a lighter weapon with a percussion lock.

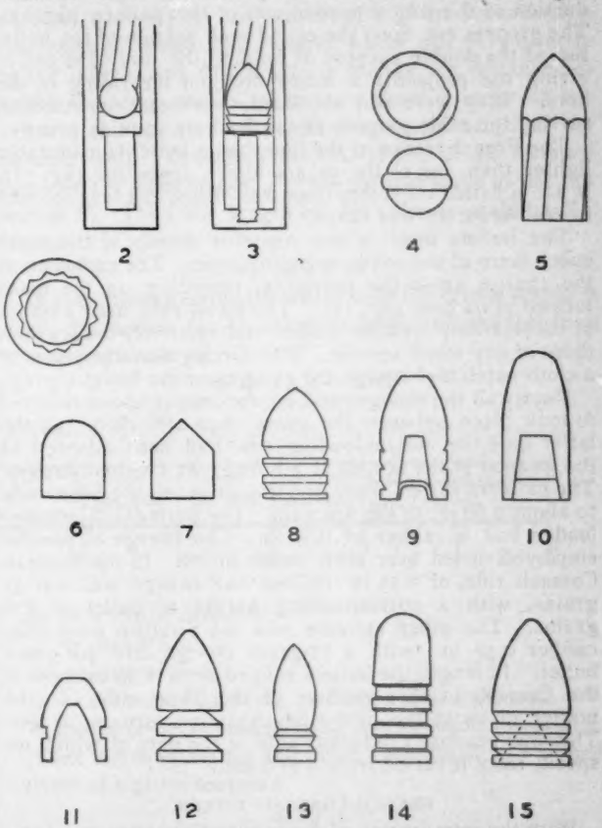
About the time of the introduction of the percussion musket the question of adopting the rifle as the military weapon began to be agitated by all the great military powers. The advantages of the rifle over the smooth-bore had been recognized. The value in both range and accuracy of giving a projectile a rotary motion was fully appreciated, and rifles in moderate numbers had long been in use. But the mechanical difficulties in the way of imparting this motion to projectiles, and the slowness with which all the rifles of the day were loaded, seemed insuperable obstacles to the adoption of the rifle as a military weapon in the hands of all soldiers, and its use was for some time confined to small, picked bodies of men, leaving the mass of the troops still armed with the smooth-bore musket.

The accompanying cuts will give a general idea of the development of the rifle, with special reference to the form and size of its projectile, and the methods employed for giving it rotation.*

In the first rifle the grooves were numerous and like the teeth of a saw (fig. 1). By using a heavy ramrod, with a mallet, the lead was driven into and made to take the grooves. With this piece loading was a slow process, cleaning was difficult, and the sharp points of the grooves soon became disfigured.

The next system adopted was that of a French infantry officer, Delvigne (fig. 2). In this the powder was contained in a cylindrical chamber considerably smaller than the bore. The bullet, smaller than the bore, was attached to a wooden sabot, which, when dropped into the bore, rested on the shoulders of the chamber. A heavy ramrod with a concave head served to force the projectile into the grooves. The sabot prevented the bullet from entering the chamber and preserved the powder grains intact.

In the *carabine à tige*, invented by Colonel Thouvenin, likewise a French officer, the chamber of the Delvigne



system was replaced by a small spindle or pin, screwed into the breech-screw (fig. 3). The length of the spindle was such as to give room for the powder charge around it, while upon its point rested the bullet. As in the preceding systems, the bullet was forced into the grooves by blows of the ramrod. In this system the elongated bullet was used, and seems to have been the first military rifle using an elongated projectile. In the early attempts to use this form of bullet the first shape given was the cylindro-spherical, next the cylindro-conical, and finally the ogee-shaped ball (figs. 6, 7, and 8).

In all the earlier systems of rifles, rotation of the bullet was secured by driving the lead into the grooves with the ramrod. This was objectionable since it disfigured the projectile and decreased both its range and accuracy. In the systems that followed efforts were made to secure rotation by other means. Two general methods were employed to this end. The first was by giving a peculiar and corresponding shape to both the bullet and the bore, and the second by forcing the projectile by the action of the powder. As examples of the first class we have the Brunswick rifle (fig. 4), in which a projection or girdle,

* In the first four cuts no attempt has been made to give the actual dimensions of the bullet; the object being simply to represent the means used to produce rotation.

formed on the bullet, corresponded to the two spiral grooves of the bore. In the Whitworth system the bore is in the form of a twisted hexagonal prism, making one complete turn in about 20 inches. To prevent stripping, the lead was hardened by alloying it with tin and manganese (fig. 5).

To obtain rotation by the action of the powder alone, Colonel Minié constructed a bullet with a deep conical cavity, and inserted in this cavity, at the base, an iron cup or *culot*. The powder gases acting against this cup forced the lead outward into the grooves (fig. 9). In the English bullet (fig. 10) the iron cup was replaced by a conical plug of boxwood. This served the same purpose as the cup, and at the same time preserved the bullet from disfiguration in transportation. It was soon found that the direct action of the powder gases acting in the cavity of the bullet was alone quite sufficient to secure rotation, and the reafter both cup and wooden block were omitted. The United States service bullet in use at the time of the introduction of the breech-loader was of this pattern (fig. 15). The grooves cut upon the cylindrical portion of the bullet served the double purpose of holding the lubricant and of giving the projectile a better hold on the rifling of the bore. They were also supposed to increase its stability, serving the same purpose as the feathers upon an arrow.

The French troops of the line used a bullet considerably lighter than any of the others above described (fig. 11). It had a flatter trajectory than was usual, but was inferior in both accuracy and range.

The bullets used in the Austrian service of the same epoch were of the solid-expanding type. The explosion of the charge *upset* the projectile, crowding up the disks formed at its base (fig. 12). The Swiss rifle used a bullet of considerably smaller caliber and relatively longer than those of any other service. The forcing was by means of a cloth patch tied around the grooves on the bullet (fig. 13).

Nearly all the changes and improvements above referred to took place between the years 1840 and 1860. At the latter date the muzzle-loading rifle had been adopted as the weapon in the armies of all the great civilized powers. The calibers varied from about 0.41 in. of the Swiss rifle to about 0.60 in. of the Spanish. The Springfield muzzle-loader had a caliber of 0.58 in. The charge of powder employed varied over even wider limits. In the Russian Cossack rifle, of 0.55 in. caliber, the charge was but 31 grains, with a corresponding weight of bullet of 176 grains. The other extreme was the Swedish navy rifle, caliber 0.57 in., with a 77-grain charge and 401-grain bullet. In length the bullets ranged from 1.39 calibers of the Cossack to 2.44 calibers of the Swiss rifle. In the matter of twist the first rifles had one turn in 20 feet. This was gradually reduced, until at the date of which we speak, 1860, it varied from 4 to 6 feet.

BREECH-LOADING RIFLES.

With the introduction of breech-loading arms an entire change in the method of forcing the projectile took place. In all breech-loading systems the diameter of the bullet is slightly larger than the diameter of the bore across the lands of the rifling, and it is slugged or compressed into the grooves on passing from the chamber into the bore of the piece.

The first breech-loader regularly adopted as a military weapon was the Prussian needle-gun, which antedated, in this respect, any other system by a quarter of a century. In 1840, when the other European powers were considering the advisability of discarding the smooth-bore for a rifle, the Prussians at once jumped over the intervening system of a muzzle-loading rifle and adopted the needle-gun breech-loader, which appeared in 1841. It made its first appearance on the battle-field in the campaign against the Danes in 1850. Its superiority over existing systems in rapidity and accuracy of fire was pronounced, but the prejudice against breech-loading arms in general was so strong that the lesson it taught was entirely overlooked. Even as late as 1863 a recognized authority on military subjects in this country, in writing of the wasteful expenditure of ammunition on the battle-field, says: "It becomes a self-evident fact that they (soldiers) fire too fast already, and that it is only adding to the evil to give them the means of firing four or five times as fast by placing breech-loading guns in their hands." The Prussians, however, held manfully to their new weapon, despite its very apparent defects. In 1864 it again justified their faith in the war with Denmark, and two years later in the war with Austria, when pitted against the muzzle-loading rifle of that power, it won so complete a victory that in that campaign it may be said to have annihilated all opposition. It was still, however, a very defective weapon. Using a paper cartridge-case, there was no obturation, and the escape of gas at the breech was great; the fulminate was at the front end of the cartridge, and to reach it the long needle had to traverse the entire length of the cartridge; it was liable to rust, and breakage was of frequent occurrence. In ballistic qualities it was inferior to many of the muzzle-loading systems, but in rapidity of fire it was far ahead of any of its rivals.

Between 1860 and 1870 M. Chassepot developed his rifle, and at the latter date we find it in the hands of the mass of the French army. The Franco-German war that followed was signalized as the first meeting of breech-loader against breech-loader in the hands of two great armies. In ballistic qualities—range and accuracy—and in certainty of manipulation the Chassepot was the better arm. But it was a contest where breech-loader, allied to the tactics of the muzzle-loading arm, was pitted against breech-loader joined to breech-loader tactics. The signal triumph of the latter is well known.

The caliber of the needle-gun was 0.61 in., with a 66-grain charge and a 451-grain bullet. The Chassepot had a caliber of 0.43 in., with a corresponding weight of powder and ball of 87 and 385 grains.

In England the muzzle-loading Enfield was converted into a breech-loader of the Snider pattern, still retaining the old caliber of .577, with a breech-lock opening to the right. This arm was replaced, five years later, by the Martini-Henry—a Henry barrel with a Martini breech-action—almost identical with the American Peabody.

In Germany, after the war of 1870–71, the needle-gun was discarded for the Mauser. France replaced her Chassepot with the Gras. Austria converted her muzzle-loaders into breech-loaders of the Wanzl pattern, and later adopted the Werndl system of breech-loaders. Russia converted her Cossack rifle into the Kruka breech-loader, and afterward adopted the American Berdan. Spain adopted the American Remington, and Italy the Vetterli.

In the United States the Springfield muzzle-loader was converted into a breech-loader (1870). The barrel was rebored, a tube inserted, reducing its caliber from 0.577 in. to 0.50 in., its length reduced by 4 in. A section of the rear end of the barrel was cut out and a breech-block inserted. This was followed by what is known as the "Springfield Rifle, Model 1873." In it the barrel was made of low steel instead of iron, and the caliber still further reduced to 0.45 in. There have been several changes of model since that of 1873, but they have been in minor parts of the arm, in the sights, etc. Essentially the arm is the same as that adopted fifteen years ago. The present service bullet is represented in fig. 14.

In nearly all of the systems here mentioned we find a reduction of caliber to about 0.43 in., and a relatively increased length of bullet from about 1.5 to about 2.5 calibers. The number of grooves in the rifling varies from three in the Springfield to seven in the Martini-Henry, with a twist of one turn in from 22 to 25 in.

With regard to the breech-loading mechanism and firing arrangement, we find the bolt system almost universal. In it the opening and closing of the breech is effected by a bolt moving in a direct horizontal line with the bore, and carrying a firing-pin with the necessary spring mechanism for firing the piece. The principal exceptions to the bolt system we find in the Martini-Henry and the Werder (Bavarian), in which there is a falling hinged breech-block with spiral or flat spring and striker; the Snider and Springfield, with a turn-over block, side lock, and striker; the Remington, with a segmental, direct block, with flat spring and striker.

These arms were sighted for ranges varying all the way from 670 yards in the Russian converted Kruka, to 2,000 yards in the French Gras—1,200 yards being about a mean.

(TO BE CONTINUED.)

THE PRINCIPLES OF RAILROAD LOCATION.

By Professor C. D. Jameson.

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(*Continued from page* 543.)

CHAPTER XLI.

NOTES AND RECORD BOOKS.

The manner of preserving all these notes in book form varies very much according to the ideas of the different engineers and the fulness that is required.

Plate LXVI is a sample page of a large cross-section book for office use which contains all the data that have been used in the calculation.

Col. 1. Numbers of stations.
" 2. Side height and distance to left.
" 3. Center cut or fill.
" 4. Side height and distance to right.
" 5. Sum of side distances.
" 6. } Values of *m* taken from Diagram for prisms
" 7. } 50 ft. long.
" 8. } Sum of adjacent readings taken from Dia-
" 9. } grams making prisms 100 ft. long.
" 10. Prismoidal correction.
" 11. } Actual amount of material per station.
" 12. }

For the use of the Resident Engineer on Construction only the data in columns *marked* 1, 2, 3, 4, 5, 6 is required in the field; that is, the full cross-section notes with the number of cubic yards of cut or fill at each station. If it is desired to use the Diagram of Triangular Prisms for estimating quantities upon railroad work, the center height *C* must be increased by the altitude of the *grade triangle*, or the triangle formed by continuing the sides of the cut or fill below or above the road-bed until they meet, thus forming a triangle the base of which is the width of the road-bed *w*, and the altitude $\frac{w}{2\,n}$, *n* being the ratio of slope of the side. We use therefore for the altitude of the triangular prism $C + \frac{w}{2\,n}$, and from the volume thus obtained subtract the volume of the grade prism, and the remainder is the volume of the required prism. As the volume and altitude of the grade prism are constant with the same width of road-bed and same ratio of slope, a table should be calculated giving the altitude $\left(\frac{w}{2\,n}\right)$ and the volume of the prism (taking the length as 100 ft.) for the different widths of road-beds and ratio of slopes that will be used.

It is not necessary to subtract the volume of the grade prism from the volume obtained for each station, but from the total volume obtained from any one cut or fill, subtract the volume of the grade prism for one station as given in the table multiplied by the length of the cut or fill in stations. For very rough preliminary work where much must be sacrificed to time, and the country is passably level, the quantities can be very rapidly estimated by using the center heights only and a table calculated for level sections.

With regard to preliminary estimates of the cubic contents and cost of the various masonry structures, diagrams can be made from which all the required information can be taken at sight. In making a diagram for an arched culvert, for instance, it can be assumed in the Preliminary Estimates that all arched culverts of the same width of opening and same class of masonry will have the same section—that is, the same number of cubic yards per foot of length, exclusive of wing walls and parapet walls. The wings and parapets will contain the same amount of masonry for the same width of opening without any regard to the actual length of the culvert. The number of cubic yards of masonry in any culvert of a given cross-section (exclusive of wings and parapet walls) will vary directly as the length, and this length is always the distance between the slope stakes minus two times a constant, the value of this constant depending upon the height of the parapet wall. Thus in Plate LXVII *C C* = the distance between the slope stakes, *P P* the parapet walls of the culvert *B B*. Then the length of this culvert would be *C C* — 2 *a*.

$$2\,a = 2\,P\,n.$$

In preliminary estimates where only the center height is used, the section can be taken as level, and the length of the culvert would be:

$$w + 2\,c\,n - 2\,a.$$

PLATE LXVI

Sta	$\frac{d}{h}$	C	$\frac{d'}{h'}$	D	Cuts from Diagram	Fills from Diagram	Cuts per Sta.	Fills per Sta	Prismoidal Correction	Actual Cuts per Sta	Actual Fills per Sta.
1	2	3	4							5	6

w = width of road-bed.
c = center fill.
n = ratio of slope.
a = constant depending on height of parapet wall.
n should never be less than 1½, and in some material 2.

Then the equation for the cubic contents of any arched culvert of a given section:

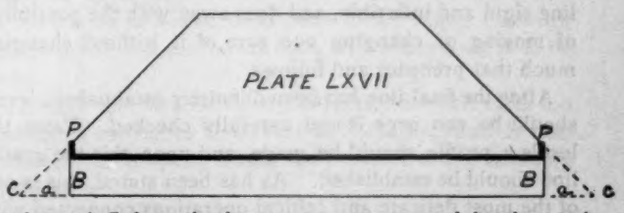
$$m = l\,s + b.$$
$$m = (w + 2\,c\,n - 2\,a)\,s + b.$$

s = cubic yards in section one foot long and includes foundation.

b = cubic yards in wing walls and parapet walls.

The diagram should be so constructed that the different

PLATE LXVII



values of *C* along the bottom are represented by the vertical lines.

The values of *m*, either in cubic yards or in the cost, will be written upon the vertical lines and represented by the horizontal lines.

Each culvert of a different cross-section will be represented by a curved line drawn diagonally across the dia-

gram. As a sufficient number of points of the curved lines representing the different culverts have to be calculated under some circumstances, it is fully as easy to tabulate the results as it is to construct a diagram, and for any ordinary work the tables needed would not be so cumbersome as to in any way impair their usefulness.

In the same manner can be calculated and constructed diagrams that shall give upon inspection the approximate weight and cost of every iron bridge, the number of feet of lumber in every wooden structure of standard type, and the amount of masonry in and cost of all open culverts, abutments, and bridge piers. By having such diagrams as these made once for all, the work of making a preliminary estimate is reduced to a minimum both as to time and expense, and a maximum of accuracy is secured.

CHAPTER XLII.

FINAL LOCATION.

The object of a FINAL LOCATION of a railroad line is to mark out exactly upon the ground the center line of the road as it is to be constructed.

From a careful examination of the plans of the preliminary lines with the contours and topographical details, the best line between the termini as to general direction can be at once decided upon and located upon paper. The alignment notes of the paper location are copied into a note-book in such a manner as to be perfectly understood by any transitman. The notes show the length and direction of every tangent, the location of the P C, P C C, P S, etc., the length and direction of every curve, together with the degree of curvature. This note-book is then sent into the field and the line re-run in accordance with the notes.

It will always be found necessary to fit the smaller details of the line to the ground in the field. That is, if a curve having a certain position, radius, and length in the paper location does not fit the ground when run in in the field as well as was expected, or if there appears any possibility of improving the line, the paper location must be abandoned at once and the best line on the ground found by repeated trials.

The line shifted to one side or the other, the relative extent of curves and tangents changed until beyond a reasonable doubt, the best line has been obtained. In this final location all the curves are run in and offsets made for the transition curves. These transition curves need not be run in until the position of the center line is definitely determined.

In making slight changes in the position of the line in final location there will be seen the great advantages to be obtained by the use of that system of transition curves that has been described over any other system that renders the line rigid and inflexible, and does away with the possibility of moving or changing one part of it without changing much that precedes and follows.

After the final line has been definitely established, levels should be run over it and carefully checked. From the levels a profile should be made, and upon this the grade-line should be established. As has been stated, this is one of the most delicate and critical operations connected with Railroad Location, and the full bearing of every question in the problem should be fully studied.

After the grade has been established the center heights at each station should be calculated. That is, the difference on the center line between what is to be the elevation of the finished grade and the actual elevation of the ground.

From data taken in the field, the angle of slope to be given the sides of every cut and fill can be decided at once, and then the slope stakes should be put in.

CHAPTER XLIII.

FINAL ESTIMATES.

When this has been done careful and elaborate estimates are to be made, and everything put in final condition for the work of construction to commence. This estimate must include the amount of each class of material to be moved, with any data possible relative to the approximate average haul, or the average distance the material must be moved.

In classification of earth-work the material is divided into three classes :

1. Earth.
2. Hard Pan or Loose Rock.
3. Solid Rock.

There is no sharply drawn line separating the one from the other. The limits of each will vary somewhat upon different roads, but the following definitions will give some general idea as to what is meant.

1. *Earth :* All material to be excavated that is not included under the heads of Hard Pan or Loose Rock or Solid Rock.

2. *Hard Pan or Loose Rock :* All boulders and detached masses of rock containing more than one cubic foot in bulk and less than four cubic yards ; all indurated clay, gravels, and shales that can be removed with picks (although the use of explosives may be the more economical).

3. *Solid Rock :* Includes all rock occurring in ledges that require drilling and splitting, and all detached masses of rock containing four cubic yards or more in bulk.

Before the work of construction has been done this classification, even under the best methods, can only be made in a general way. The object of it is simply to allow a fair estimate to be made of the probable cost of the work, and also in order that contractors may be able to make intelligent bids for the future work.

The ESTIMATE OF QUANTITIES should be made with much more care than was necessary in the preliminary estimates.

Where the surface of the ground is very uneven and the work in rock, or for any other reason liable to be very expensive, the cross-section at each station and at intermediate stations should be very carefully plotted, and the areas of the cross-sections taken exactly from the plot by means of the PLANIMETER. A full description of this little instrument can be found in the catalogues of some of the instrument dealers. In general terms, it is a mechanical integrator having two arms and a registering disk, with the other details so arranged that if one arm is fixed to the plan and the pointer on the other moved around the boundary line of any shaped figure, regular or irregular, the index will give the exact area of this figure, either in square inches or any required units according to the adjustment of the machine. When the final location has been made in all its details, slope stakes and all other necessary stakes put in, estimates and classifications made, with all needed plans and profile, the railroad passes out of the hands of the LOCATING ENGINEER into those of the ENGINEER IN CHARGE OF CONSTRUCTION, and everything is ready for the work of construction to commence as soon as specifications have been made out and contracts let.

CHAPTER XLIV.

PRESERVING RECORDS OF LOCATION.

There are two other points upon which we must touch before we close, and that is the records that should be kept by the railroad company of the work done on location, and of all the real estate owned by the company.

With regard to the preservation of the notes of the work done on location, it may be said that all of these notes should in the end be forwarded to the main office, together with the plans and profiles used in the field. There are very few of these plans and profiles but that at some time may be of inestimable value to the railroad company. All of these original notes should be most carefully preserved, not only in their original form, exactly as sent in from the field, but also by exact copies of them made in ink.

It will at once be seen that every effort should be made by the field engineers to make these notes as full and explicit as possible. Let every point that can in any way have a bearing upon questions that may arise in connection with the future road be most carefully noted. Give the dates upon which all the work was done, with the names of the rod men, instrument-men, and engineer in charge, and any circumstances connected with the doing of the work that can possibly ever be of any use.

Many of these points may seem very small and unimportant matters about which to take so much trouble, but no one can tell of what inestimable value they may prove to the road at some future time. At any rate, the amount of extra labor and possible extra cost (and this extra labor and care by no means necessitates any extra cost, but is dependent upon the habits of instrument-men with regard to taking notes) entailed by this noting of every possible point of future importance is very small, and if the time should ever come when one only of the minor points of information should be needed, the benefit to the road from having it recorded in a convenient and authentic manner would undoubtedly repay the railroad company many times for the extra cost and trouble of obtaining and preserving *all* of these minor points.

There should be at least two copies of all the original notes and tracings or blue-prints of all the plans. Since the general introduction and adoption of the blue-printing process, after one tracing has been made of any plan there is comparatively little work in multiplying these copies to any extent, and absolutely no excuse for not preserving a sufficient number of copies.

There should be at least two sets of very highly and elaborately finished plans, showing the center line of the road, all the switches and side tracks, stations, etc., the exact boundary lines of all the right of way or property owned by the company along the line of the road, with the boundary and division lines of all the adjacent properties and the names of the owners. These finished maps should show every opening in the road and the means by which it is to be passed, and as much topography or contour lining as possible. These plans should be made upon sheets of such a size as to permit of their being bound into book form. Either 24 in. or 18 in. wide by 36 in. long is a good size. The scale should be such as to allow about two miles to a sheet. The center line should run around the center of the sheet, with every change in the alignment clearly noted. There should be drawn the limits of the right of way and all line fences. Below this should be the profile, showing the natural surface of the ground, the grade line, and every opening in the track. On the grade line should be marked clearly the rate of grade and the elevation of every point where the rate of grade changes.

The remainder of the sheet should be filled up with detailed plans of any of the smaller stations that come in that portion of the line shown upon the sheet. These station plans should be on a much larger scale than the general plan of the road. Much of the work that must in the end go upon these finished maps cannot be done until the work of construction is finished.

CHAPTER XLV.

REAL ESTATE.

With regard to the REAL ESTATE that may be acquired by the company, it may be said that when any piece of property is deeded to the company the engineer should prepare a complete plan of it, and write out a full description, which should be inserted in the deed. Then this description should be copied into the *Real Estate Record Book*, together with the character and number, where recorded, and the date on which it was recorded; any particulars as to the manner of purchase, price paid, terms of payment, names of both parties to the transaction, date of purchase, and any other particulars in connection with the purchase that may be deemed necessary. There should be made two copies of this *Right of Way Book*, one to be kept in the fire-proof safe of the Treasurer of the railroad company, and the other copy in some secure fire-proof place not in the same building as the Treasurer's office. The plans, specifications, and bills of material of all the structures should be preserved with care, and in such a manner that they can be referred to when needed with no loss of time and without the necessity of overhauling the entire stock of plans that the company possesses before the required one can be found, as is too often the case on many of our otherwise well-managed and orderly railroads.

CHAPTER XLVI.

THE CONTRACT.

Before construction can commence on any part of the road it is not only necessary that complete and accurate plans and profiles should be made showing exactly the amount of work to be done and the result to be obtained, but these plans and profiles should be accompanied in every case by full and explicit specifications, stating the manner in which the work is to be carried on and finished, defining fully the material to be used in each case, and the degree of excellency to be attained—that is, while the plans and profiles show exactly *what* is to be done, the specifications show the *manner* in which it is to be done, and establish a standard below which none of the finished work can fall.

These are all followed by the CONTRACT, which is simply an agreement between the railroad company and the contractor as to the conditions under which the work is to be done, and the terms upon which payment is to be made.

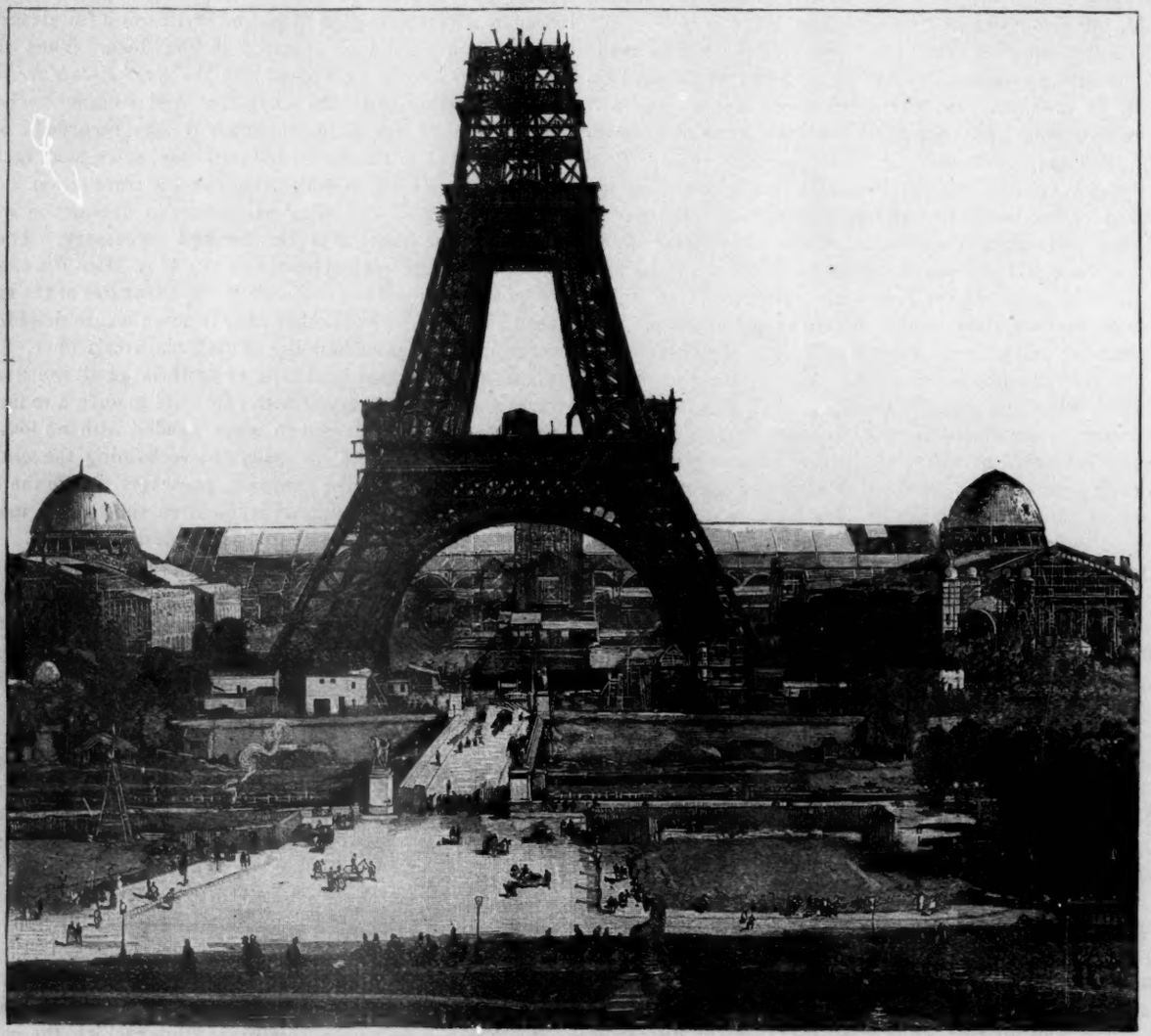
Railroad specifications and contracts, however, form too extensive a subject to be treated in a chapter, and do not, moreover, fall properly within the province of the Locating Engineer.

The writer trusts that those readers who have followed these articles during the past year and have studied the methods of Locating a Railroad, will not be indisposed to continue those studies and to consider some practical hints on the Construction of the Railroad and its auxiliary works.

THE EIFFEL TOWER IN PARIS.

(From *Industries.*)

On November 1 the great Eiffel Tower now under construction on the Paris Exposition grounds had attained a height of 178 meters (587 ft.), and the present rate of progress is at the rate of 36 ft. per week. If this be maintained, the whole of the principal parts of this immense structure will be erected by the end of January, 1889. Meanwhile the decorative and accessory parts of the work are not neglected, and there is every prospect that the tower will be completed in all its details at the opening of the Exhibition. We give in the accompanying illustration a view of the tower as it appeared when seen from the opposite side of the river at the beginning of November. The illustration also shows some of the principal buildings now in course of construction on the grounds of the Exhibition. The erection appearing like a tower in the background, within the center arch of the Eiffel Tower, is the lower portion of the large dome which rises above the main entrance to the Exhibition; the long building at the back is the large machinery hall, extending right across the Champ de Mars; the building on the right of the tower, with a cupola, is intended for the exhibition of liberal arts; and the corresponding building, on the left, for that of the fine arts. At the foot of the tower, and along the quay, there are now in course of erection various buildings, which will also form exhibits, the intention being to bring before the visitor a comprehensive collection of human dwellings, and in that way illustrate the development and history of domestic architecture.



THE EIFFEL TOWER AT THE PARIS EXPOSITION.

THE ABT RACK-RAIL SYSTEM.

In a recent number of the JOURNAL (October, 1888, pp. 442–443) the rack-rail system for mountain railroads devised by Herr Roman Abt, the best system of the kind yet introduced, was illustrated and described. In an article recently published in the Vienna *Zeitschrift für Eisenbahnen und Dampfschiffahrt*, Herr Abt gives an elaborate argument in favor of his system, which lack of space prevents us from reproducing, and adds the following account of recent progress made:

A rack-rail road on the principles laid down by me, which has been in operation for a year, has given much satisfaction, and has, in view of the ascertained results, this summer received the first prize (7,500 marks) given by the Union of German Railroad Managements.

The first example of my system was built under the management of Herr A. Schneider, Director of the Brunswick Ducal Railroad, and is an extension of

the Halberstadt-Blankenberg line into the Harz Mountains.

The toothed rack or rack-rail is made in three parallel plates or bars 20 mm. thick and 110 mm. high. The distance between these bars, as in all the later lines, is 120 mm.; the length of each rail is 2.640 meters, and each rests on four cast-steel chairs fastened by lugs and keys to iron ties, while two bolts secure the rack-rail to each chair.

The locomotives have three pairs of coupled adhesion wheels, and under the foot-board a pair of bearing wheels, making a steady-running machine. The rack-rail machinery consists of two coupled axles carrying the toothed wheels, which are supported by an additional frame suspended from the two outside driving axles, and this frame can be removed for repairs without dismounting the adhesion axles. A pair of inside cylinders serves to drive these axles, and also, when the rack-rail is not in use on the level portions of the road, acts as an air-brake to regulate the speed.

The success of this first line led to the building of others. In 1885 Herr Oertel built a connecting line of standard gauge on the Abt system from the Harz Railroad at Lehesten station to his slate quarries at Oertelsbruck, and in his quarries he has also a system of narrow-gauge lines. On this main line the rack-rail consists of two bars, each 20 mm. thick and 110 mm. high, on iron ties, while on the narrow-gauge lines it is also of two bars 15 mm. thick and 110 mm. high, on wooden ties.

The locomotives for the standard-gauge line have two pairs of coupled adhesion wheels and one pair of driving wheels, the rack-rail axles, wheels, and cylinders being arranged as in the locomotives on the Harz Railroad, above described. The small narrow-gauge locomotives have two pairs of adhesion wheels and one toothed wheel, the three axles being coupled and worked by the same cylinders.

This arrangement seems to be desirable only on a locomotive of this kind which has short runs to make, where the rack is constantly in use.

In 1886–87 there was built the road from Puerto Cabello to Valencia in Venezuela. For the crossing of the high ridge of Las Trincheras between the two places a section of rack-railroad 3.8 kilometers in length was put in. The rack-rail on this line is in three bars, 22½ mm. thick, placed 40 mm. apart.

The locomotives are rack-rail engines only; they are carried on three pairs of bearing wheels, and have two driving axles carrying the toothed wheels. There are four cylinders, one pair to each driving axle.

The English Government in 1887 ordered for the military road through the Bolan Pass, in India, 11.3 kilometers of rack-rail, to be of the same dimensions and of equal strength with that used on the Harz Railroad. The locomotives are of similar construction and strength, with this improvement, that the axles for the toothed wheels are driven directly, without an auxiliary shaft, and the frame carrying these axles is fixed on the two forward adhesion axles without hangers.

The principal dimensions and particulars concerning these roads are given in the following table:

Road.	When built.	Gauge, meters.	Length in Kilometers.		Grade, Per Cent.		Least radius of curvature, meters.	Weight of locomotive, tons.	Weight of load, tons.
			Rack-rail.	Total.	Ordinary road.	Rack-rail road.			
Harz.....	1884–86	1.435	7.8	30.5	2.5	6.0	180	56	120
Lehesten.....	1885	1.435	1.3	2.7	3.1	8.0	150	23	50
Oertelsbruck....	1885	0.690	0.5	10.0	3.5	13.7	120	6	6
Puerto Cabello to Valencia.....	1886–87	1.067	3.8	56.0	.....	8.0	180	38	60
Bolan Pass.....	1887–88	1.676	11.3	.....	2.5	4.2	180	54	175

The next example of this system will be in Austria, where a concession has been granted for a branch line from Eisenerz to Vordernberg, which will be finished in 1890.

This Eisenerz-Vordernberg line will have a total length of 20 kilometers, of which 14.5 kilometers will have the rack-rail, which in this case will consist of two plates or bars 27 mm. thick. The heaviest grade worked by adhesion will be 2.5 per cent.; on the rack-rail section there will be grades as high as 6.8 per cent., or 359 ft. to the mile.

The locomotives will be similar in construction to those of the Harz Railroad, with several improvements of essential importance.

It will be remembered that Herr Abt's latest improvement consisted of an arrangement which was fully described in the article above referred to, by which a train can pass from the ordinary track upon the rack-rail section, and the rack engine can be put in operation, without stopping, so that the introduction of a short section of rack-rail in a road will cause no delay or stoppage.

NOTES ON RIVER CROSSINGS AND BRIDGE PIERS.

By M. Otagawa, M.E., Tokyo, Japan.

(*Continued from page 545.*)

VI.—FORM AND THICKNESS OF PIERS.

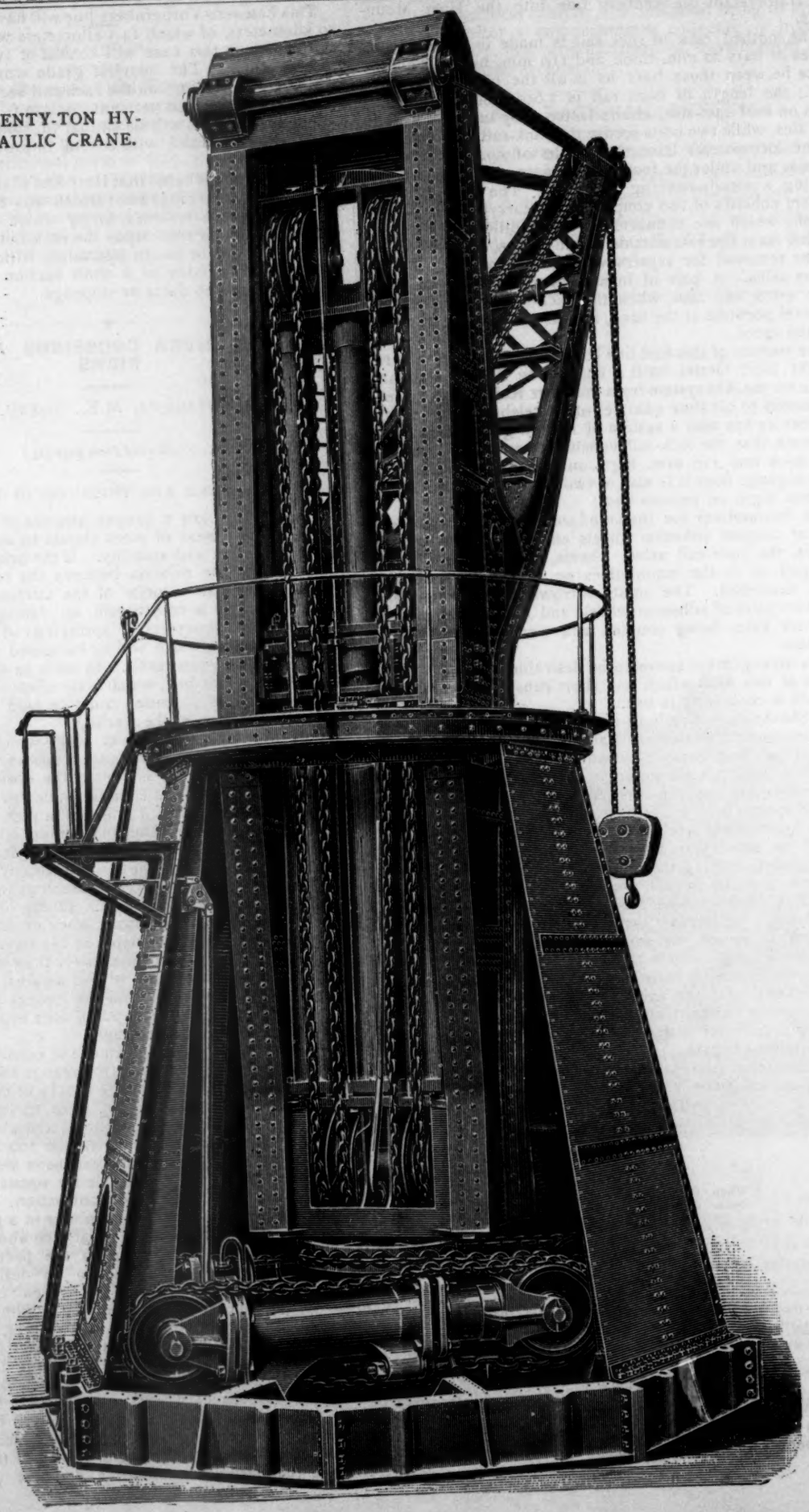
In order to allow a proper amount of water-way to a bridge, the thickness of piers should be as small as practicable consistent with stability. If the bridge has a water-way such that the relation between the resistance of the bed and the mean velocity of the current is not altered before the bridge is constructed, no damage results. But in cases where the piers or springings of the arches obstruct the current, there will be increased velocity, which produces a dangerous result. In order to avoid the undermining of the river-bed, which is the effect of contraction of the sectional area, attention must be paid not only to the size but to the form of the starling.

There are various forms of piers which are actually built. Our present object is to determine the most suitable shape of starling, as far as the obstruction is concerned. The problem is equally applicable to the head of a jetty as well as to the starling of a pier, on account of the similarity of the circumstances under which they exist. In determining the proper shape of piers, it must be borne in mind that masonry work when totally immersed in water weighs only three-fifths as much as in the air. The river-bed is porous to a certain extent, and there is an action like a spring, the elastic force of which is equivalent to the pressure of the depth of the river. Such being the case, if there be some means for the escape of such a force, the upward pressure will act against any structure which is within its reach, and the force is so great when such a void extends to the depth of four or five feet that it often lifts up an enormous weight.

In addition to the above, we have to consider the matter in other respects—*i.e.*, we have to arrange the piers so that they will not be damaged by the shocks of floating objects such as ice, timber, boats, etc. For this purpose great solidity must be given to the starlings, and at the same time their projecting angles must be neither too acute nor too flat, for in the former case they will soon wear away, and in the latter they are not suitable for opposing masses of ice. In order to reduce the contraction, the starlings should be made very long and terminate in a point. Thus, we see that it is impossible to satisfy the above conditions at the same time. According to the peculiar circumstance under which the pier is to be designed, proper consideration must be made. To prevent contraction as much as possible, the surface of the starling should not make an angle with the flanks of the pier, but the side faces must be continuous with the faces of the starlings. This condition can be fulfilled by making the starling a convex curve and the flanks tangent planes to the curve.

For the purpose of determining the best form of starlings, experiments have been made by many hydraulic engineers. The forms of starlings with which the experiments were made are rectangle, triangle (rectangular), triangle (equilateral), semi-circle, triangle (mixtilinear),

TWENTY-TON HYDRAULIC CRANE.



ellipse, triangle mixtilinear concave, etc. These experiments show that whenever the flanks of the pier are connected to the starling by a curve which is a tangent to them, the water does not surmount the springing of the arches, and there is no fall produced at the shoulder, but two other currents are formed by the side which surround the pier. The velocity in that case is not great, and the rapid currents are more remote from the pier. The elliptical pier is advantageous on account of producing less contraction compared with other forms. In the case of an equilateral triangular pier, the greatest fall occurs at the angle of the shoulder; but in a rectangular one, at a point a little removed from it. In the former there is a deficiency in solidity. The equilateral triangle mixtilinear has the combined advantages of producing the smallest amount of contraction, having at the same time sufficient solidity at the projecting angle. For the same reason an oval pier is also preferable.

Hitherto we have only considered the suitable form of piers with respect to the amount of contraction caused in the current. But we must not neglect another important function which it ought to perform, more especially in cold climates—*i.e.*, the starlings must be so designed as to be capable of breaking the ice. If this precaution be not taken, a large mass of ice is suspended in front of the piers, and scouring results. For the purpose of preventing such a difficulty the angles of the starlings must be made acute, and to insure solidity it is advisable to protect them by bands of iron or by iron bars placed in the masonry work.

The method adopted by Perronet for overcoming the difficulty resulting from ice for the bridge over the Neva at St. Petersburgh is this: The projecting edge of the starling was made so as to incline forward. Now the masses of ice which strike the pier have a tendency to mount along the edge of the pier. This being the case, their own weight acts on each side, and the result is that they are broken and are carried off by the current.

It is found by experience that as the water comes to the bridge it is locally elevated and gains greater velocity. But in passing below the bridge it recovers its original level and velocity. Although the form of starling down stream is a matter of secondary importance, still the neglect of it produces stagnant water, which is to be occupied by it, and the result is that undermining takes place above the bridge. In order, therefore, to get the full benefit from the starling, it must be provided on both sides of the pier.

What was mentioned in the above paragraphs applies with equal force to arched bridges as well as other types of bridge. But in the case of an arched bridge, when the water level is above the springing of the arch the circumstances altogether vary. In that case we must also consider the manner in which the intrados of the arch is connected with the face of starlings more particularly than the form of the starling itself, for then the latter has little to do with contraction, while the former is the principal element of the obstruction.

If the pier of an arched bridge be designed to be stable when the thrust of the arch comes from one side only—*i.e.*, an abutment pier be adopted, then the thickness ranges from one-fourth to one-tenth of the span. It thus occupies an enormous space. If the arches be built symmetrically with respect to a pier during its construction, the pier may be thinner. According to Dr. Rankine, the thickness for an ordinary pier is said to range from one-sixth to one-seventh of the span.

In bridging over a stream, almost every new situation requires a special design. The superstructure and the piers are two principal parts into which the design may be divided. Their relative importance can be determined by the physical character of the river, the nature of the river-bed, and other conditions of the site. The cost of the superstructure increases as the length of the spans. Therefore, if the bed of the river is of a reliable nature, such as rock, gravel, or hard clay, in which the foundations can be easily constructed, a short span would be economical. But in many cases it is difficult to build piers under water, especially when the foundation is hard and the current is rapid. The most economical span should be decided upon in each particular site. But in navigable rivers or in rivers which are subject to heavy floods, it is necessary to diminish the number of spans in the stream as much as possible. In some cases the number of piers must be reduced not only from the costly nature of the foundations, but also from the shortness of the season suitable for erecting them.

VII.—EXAMPLES IN JAPANESE PRACTICE.

I now propose to conclude these notes with some remarks bearing upon the cases of bridges which were actually built over large rivers in the neighborhood of Tokyo. When railroads were first introduced into Japan, the most difficult case was the Rokujo River crossing on the Tokyo-Yokohama line. The river was first crossed by a temporary wooden bridge. In selecting a site for the new bridge, which was laid out so as not to interfere with the original one, the line was diverted, with short curves on both sides of the river, and the new alignment was less oblique to the main channel of the river than the original one—that is to say, the angle of obliquity is 75°. It was further considered desirable that greater headway should be given than had been allowed in the original bridge for excessive floods, and an increase of the gradients on both side of the river was made. The rail-level thus attained was 20 ft. above the ordinary high-water mark and 6 ft. above the highest known flood level.

Before the Rokujo Bridge was constructed a careful examination was made with respect to the flood discharge and the general regimen of the river, from which the proper length of the bridge was estimated. The dimensions are as follows, measuring from the north abutment:

23 spans of 40 ft. clear	=	920 ft.
1 span " 38 " "	=	38 "
6 spans " 92 " "	=	552 "
Total water-way	=	1,510 ft.
23 piers 4 ft. thick	=	92 ft.
6 " 8 " diameter	=	48 "
Total space between abutments,	=	1,650 ft.

Thus, the piers occupy about 9 per cent. of the total space between the abutments.

Next, for the bridge over the Arakawa, already referred to, we have, measuring from the north abutment:

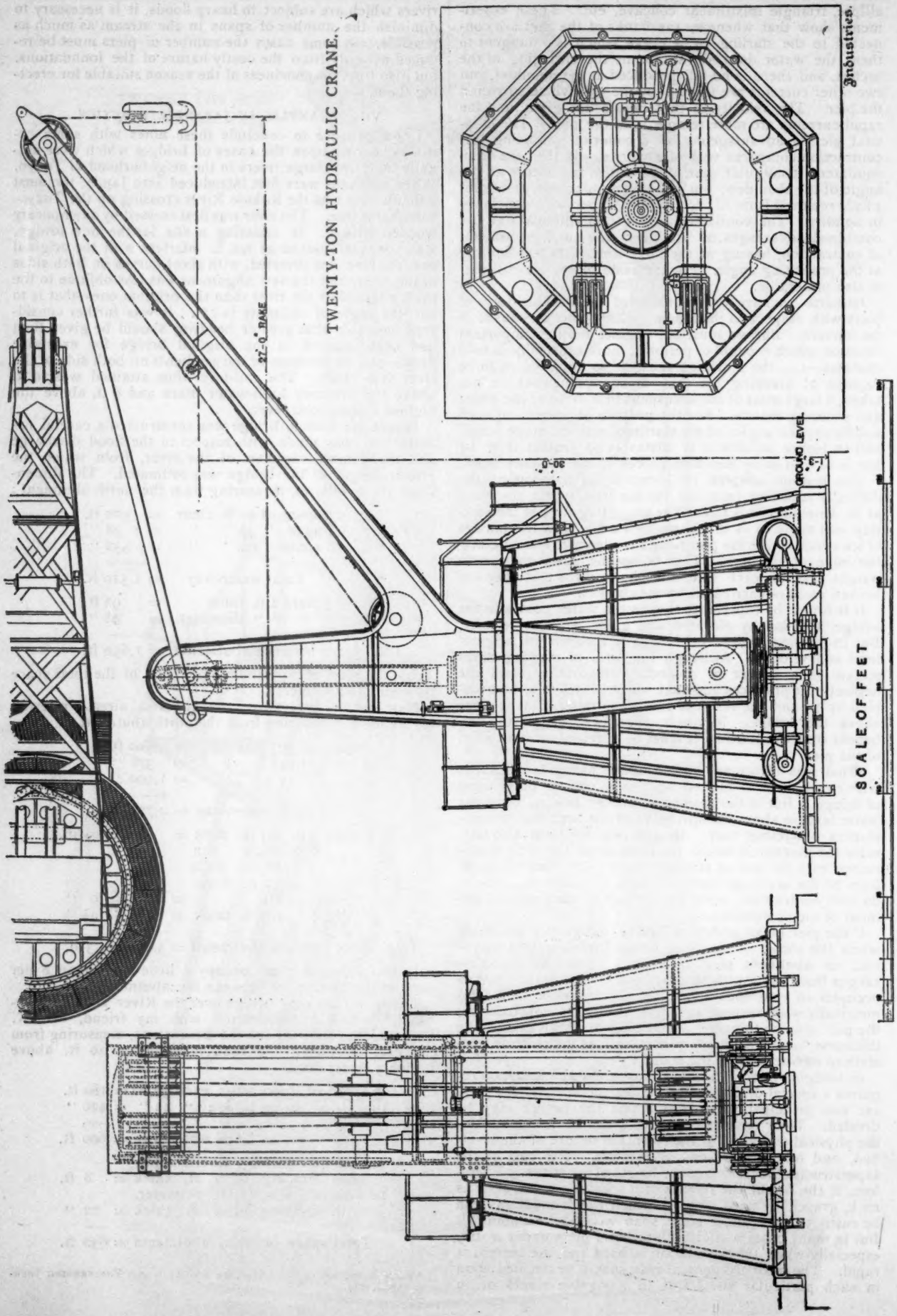
10 spans of 50 ft. clear	=	500 ft.
4 " " 94½ " "	=	378 "
38 " " 50 " "	=	1,900 "
Total water-way	=	2,778 ft.
9 piers 4 ft. 10½ in. thick	=	43 ft. 10½ in.
5 " 6 " thick on brick wells 12 ft. diameter	=	30 " 0 "
37 " 4 " 10½ in. thick	=	180 " 4½ "
Total space between abutments	=	3,032 ft. 3 in.

In this case the piers occupy a little more than 8 per cent. of the total space between the abutments.

Lastly, for the road bridge over the River Tone at Maebashi,* which I constructed with my friend, Mr. K. Shibuya, the following are the dimensions, measuring from the east abutment, the road level being 40 ft. above ordinary water level:

2 spans of Howe truss, each 90 ft.	=	180 ft.
10 " " beam bridge " 42 "	=	420 "
Total water-way	=	600 ft.
2 cast-iron piers, 3 ft. diameter, with bracing of 1 ft. thick	=	8 ft.
10 wooden piers, 1.5 ft. diameter, with bracing of 7 ft. thick	=	22 "
Total space between abutments	=	630 ft.

* For a description of this bridge, see RAILROAD AND ENGINEERING JOURNAL, April, 1887.


TWENTY-TON HYDRAULIC CRANE.
Industries.
27'-0" RAKE
30'-0"
GROUND LEVEL
SCALE OF FEET

Thus the piers in this case occupy about 5 per cent. of the total space between abutments.

As has been explained in the previous paragraphs, in obstructing a certain portion of water-way by piers, the river has a tendency to compensate for its lost area by undermining the bed, so that it is often necessary to build some form of protection through the whole width of the bottom; then every part shares the uniform resistance and the current does not damage any one pier more than another. For this purpose I have constructed crib-works, fascine-works, stone pitchings, "jakago" (basket-works of bamboo filled with stones), etc., round the pier and also through the width of the river, which answered the purpose well.

TWENTY-TON HYDRAULIC CRANE.

(From *Industries.*)

WE illustrate herewith a hydraulic crane, constructed by Messrs. Stothert & Pitt, Limited, engineers, Bath, for the State of Kattywar, India, which is capable of lifting 20 tons through a height of 40 ft., the distance of the hook from the center of the pillar being 27 ft. The lifting power is effected by three cylinders and rams placed vertically between the sides of the revolving pillar. The rams have a diameter of 12¾ in., and a stroke of 10 ft., being one-fourth of the range of lift given to the chain hook. In order to economize water when dealing with light loads, the lifting power may be varied by putting pressure on one, two, or three of the rams, as required, thus giving three powers of lifting, for loads up to 7, 14, or 20 tons respectively, the water pressure being 700 lbs. per square inch. The lifting chain is double, with an equalizing pulley and counterweight, to overhaul the slack, placed immediately above the hook. The revolving pillar with jib is rotated by two cylinders and rams placed horizontally in the basement of the pedestal on either side of the central footstep. These are geared by means of chains to a cup drum fixed to the foot of the pillar, and have a length of stroke sufficient to turn the crane through a complete circle in either direction. The valves are placed in the basement of the pedestal, and all the operations of working, lifting, lowering, and slewing in either direction, are performed by means of two hand levers. These levers are placed on a working platform near the top of the pedestal, in a position which gives the driver a good view of the load.

The pedestal is constructed of steel plates and angles, octagonal in shape, and stiffened by vertical ribs and horizontal gussets. It is bolted down to a massive cast-iron base plate, and carries at its upper end a cast-iron roller path, on which a live ring of rollers runs. The revolving pillar and jib are constructed of steel, and the height of the jib pulley above the level of the wharf on which the crane stands is 37 ft. The hydraulic pressure is obtained from an accumulator through the existing mains, but a set of hydraulic pumps were supplied, driven by a portable engine, for working the crane at times when the supply from the mains is not available.

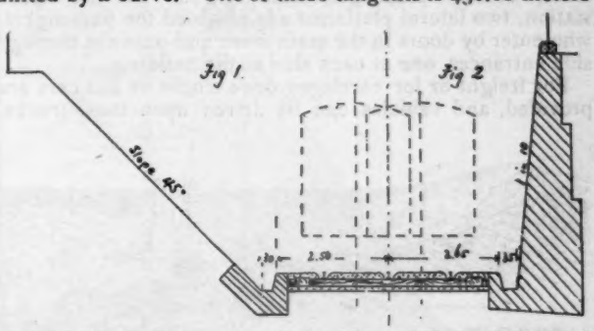
We are informed that the crane was tested with these pumps at the makers' works, with a load of 20 tons, and all the operations were satisfactorily performed. The crane was ordered by Mr. R. Proctor Sims, C.E., the Superintending Engineer to the State of Kattywar, and the work was carried out in England under the superintendence of Mr. J. R. Manning, C.E.

A FRENCH CABLE RAILROAD.

(From *Le Genie Civil.*)

THERE is a considerable movement of passengers daily between the center of the city of Lyons and the heights of Croix-Rousse. To provide for this in some degree there was built in 1878 a cable railroad from Fourviere to Saint-Just. This has been of great service to the city, but 10 years' experience has shown that it served really only about one-third of the people who every day go to the Croix-Rousse. The rest of the movement passed by way of the Grande Cote and Saint Sebastian. It was therefore decided that it would pay to build a second cable road near Mt. Saint Sebastian, starting from the Croix-Paquet, which is a center toward which there is a large daily movement of passengers. A concession was accordingly obtained from the Government in December, 1887, for such a line, as a railroad of local interest.

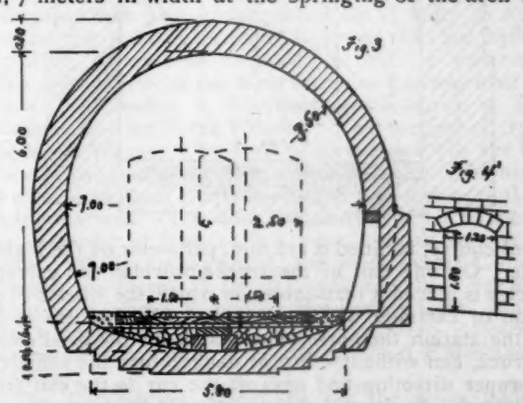
The line starts from the Croix-Paquet at one corner of the Public Garden and at the meeting of three of the principal streets of the city. The road consists of two tangents united by a curve. One of these tangents is 436.10 meters



and the other 48.72 meters in length, and the entire length of the line is 518.81 meters. The height above water-level at the starting point is 173.03 meters, and that of the upper end of the road is 249.43 meters, so that the vertical rise is 76.40 meters. The radius of the curve is 250 meters, and the maximum grade is 17.2 per cent.

Leaving the starting point, the line crosses the Public Garden from the Croix-Paquet station; this station faces on an entrance court, which is in an excavation of 43 meters in length, bounded partly by a retaining wall and partly by an earth-bank, the slopes being sodded and planted with trees, in order not to interfere with the general appearance of the Public Garden. Just beyond the station foot passengers can cross the track on a handsome iron bridge.

The line then passes at once into a tunnel of arched section, 7 meters in width at the springing of the arch and



263 meters in horizontal length. The floor or bottom of the tunnel is an arc of a circle 7 meters radius. This tunnel passes under several streets, and the line finally leaves it and returns to the open air on private property. From the upper portal of the tunnel it is in an open cut, sometimes with retaining walls and sometimes with a bank having a slope of 45°.

The necessity of having the terminal station facing on the Boulevard Croix-Rousse embodies the necessity of a curve of 250 radius, joining the two tangents.

The road is constructed for two tracks, but, in order to diminish as much as possible the expense, and also to reduce the space taken from the Public Garden, the two tracks are laid close together, as has been done on the cable railroad at Glion, in Switzerland, where the interval between the two tracks is only 0.131 meter. Here this interval has been suppressed altogether, except for a dis-

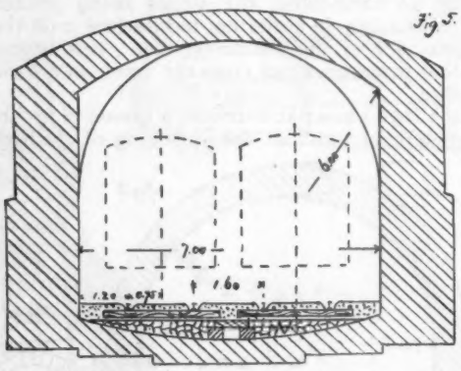
tance of about 38 meters at the Croix-Paquet station and at a passing-place about half-way, where an interval is introduced and a double track made for a distance of 52 meters. At other points three rails are laid, the center rail serving for both tracks, as shown in figs. 1, 2, and 3 herewith; at the stations and at the passing-place the interval between the two tracks is 1.60 meters, as shown in fig. 5, the ends of this double track being joined to the three-railed line by curves of 100 meter radius.

There are two stations, known as the Lyons and the Croix-Rousse, one at each terminus. A third one may be established at the central point or passing-place hereafter, but it is not yet considered necessary. The stations are used both for passengers and freight. At the Lyons station, two lateral platforms are provided for passengers, who enter by doors in the main front and pass out through side entrances, one at each side of the building.

For freight or for carriages open trucks or flat cars are provided, and vehicles can be driven upon these trucks, entering the station through special gates. Freight is not carried on Sundays or holidays, and the freight trucks are then transformed into passenger cars by means of movable seats and railings placed on the car.

The station buildings are of iron with brick foundations.

The cars, both passenger and freight, have their floors horizontal at the stations, and in passing over the road



are, of course, inclined 0.172 mm. per meter on the highest grade. On one end of the trucks provided for carrying vehicles is placed a turn-table, on which the wheels of the wagon or carriage will rest, so that when the car is run into the station the horse, who stands on the fixed end of the truck, can without effort or danger turn the vehicle in the proper direction and pass off the car to the exit from the station. At the end of the station at the starting point there is provided a car-house, large enough to contain a freight truck and a passenger car. These cars when needed are put in service by a special arrangement for switching.

The engines which drive the cable are placed in a special building and the cable is carried over drums in a subterranean conduit. The engineer is so placed that he can see the trains in motion from the time they pass out of the tunnel until they arrive at the upper station.

In the accompanying sketches, which are given as of interest in showing the manner in which the work is carried out, fig. 1 is a half-section of the road in open cut, with earth-bank; fig. 2 a half-section of the open cut with retaining walls; fig. 3 a section of the tunnel; fig. 4 shows the recess provided in the tunnel for workmen, etc., and fig. 5 is a section of the tunnel at the passing-place or central point, where a space is left for a double track. The profile and plan of the road are not given, being very simple and easily understood from the description.

THE VYRNWY DAM.

(Condensed from *Industries*.)

THE accompanying illustrations show the dam on the Vyrnwy River, in Wales, built in connection with the works for furnishing an additional supply of water to the city of Liverpool. This dam forms a lake about 4¼ miles long, the total surface area when full being 1,121 acres and the greatest depth 84 ft., the storage capacity being about 12,000,000,000 gallons.

As shown by the illustrations, the dam extends across a narrow valley, its total 1,173 ft. To determine the exact position of the rock at the site chosen for the dam 13 shafts were sunk and 177 borings were made through the alluvial

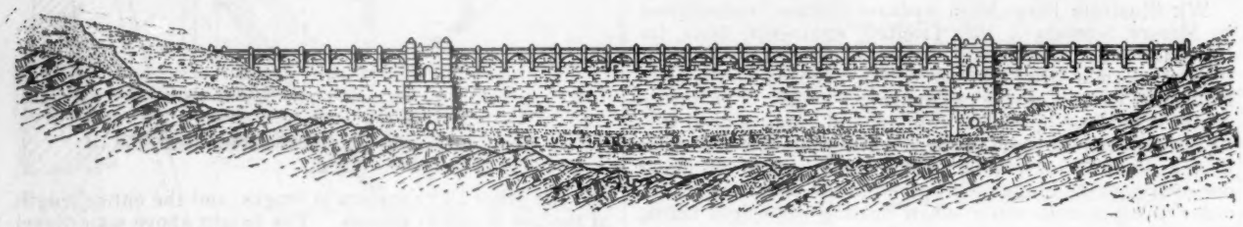


Fig. 1.

deposit, and when the rock was subsequently bared it was found to extend, as had been anticipated, right across the valley. The strata dip toward the upper end of the valley. When the rock was exposed, the glacial action was very apparent, for the outcrops of the strata had been crushed off by the flowing mass, and immense masses of the rock, some several hundred tons in weight, were found lying on the top. These, however, were all removed, and the dam rests upon the solid rock; all doubtful surfaces and long projecting outcrops having been quarried out. A cross-section of the valley, on the lower side of and near to the dam, is shown in fig. 1, where the shape of the surface of the rock, the alluvial deposit, and the back of the dam is clearly shown. A cross-section of the dam is shown in fig. 2, with the leading dimensions of a typical section, which are as follows: Width of base outside toes, 117.75 ft.; height from base to top of dam at overflow, 128 ft.; height to top string course of viaduct, 136 ft.; height from base to back-water level, 45 ft.; maximum depth from top of dam to lake bottom, 84 ft. The area of the typical section is 8,972 sq. ft.; its weight per lineal foot is about 645 tons; its specific gravity is 2.57; its center of gravity is 47.59 ft. above the base, a vertical line from it cutting the base 47.53 ft. from the inner toe, and 70.22 ft. from the outer toe. From Mr. Deacon's calculation, it appears that when the lake is empty the maximum pressure occurs at the inner toe, and is equal to 8.7 tons per square foot, that on the outer toe being only 2.26 tons per square foot. When the lake is full, the resultant pressure gives a maximum pressure at the outer toe of 6½ tons per square foot, and under no possible condition could it exceed 15½ tons per square foot. The total length of the dam is 1,173 ft., and above the overflow level is constructed a viaduct 22 ft. wide on stone arches, through which will flow the excess of water into the basin at the back of the wall, and on to the River Vyrnwy. The east end of the dam is built into the solid rock; but as the rock was too far away at the west end, the joint will be made with puddled clay.

The class of masonry adopted is generally known as "Cyclopean rubble," the stone—a clay slate of the Caradoc group of the Lower Silurian—being obtained from the quarry, about a mile from the site of the dam. The stone is a hard, durable, dark gray stone, weighing 2.06 tons per cubic yard, the cleavage being very irregular, making it almost impossible to obtain a rectangular block. The maximum weight of the blocks is about eight tons, and each stone is carefully scrubbed and washed with water, at a pressure of 140 lbs. per square inch, before leaving the quarry. The bed of the valley contains excellent sand

for cement, mortar, and gravel for the concrete, the following being its chemical analysis :

Water	2.3
Silica (combined)	65.7
Oxide of iron as silicates	12.4
Alumina	13.4
Lime	2.4
Magnesia	0.68
Alkalies	3.8
Total	100.68
Errors	.68
Total	100.00

It was afterward found that refuse from the quarry, if crushed and mixed with the natural sand in the proportion of two to one, made a stronger mortar ; and the sand for the mortar has been made from this mixture since 1884. Very ingenious' apparatus for washing the sand was devised by Mr. Deacon, by means of which the clean water entered the end of the rotating cylinders at which the washed sand left it ; the internal screws pushing the material to the top of the inclined cylinder against the water, falling by gravity. The dirty water thus left the cylinder with the refuse.

The whole of the mortar and concrete is made of Portland cement, made to the following specification : 90 per cent. of the cement to pass through a sieve with sixty brass wires per lineal inch weighing 3¾ oz. per square foot. Briquettes, eight days after being moulded and kept in water from the second to the seventh day, to withstand for an hour, without fracture, a weight of 560 lbs. per square inch. The actual average test of over 1,000 briquettes has proved to be 700 lbs. per square inch.

Three cubes of the rock were tested by Professor Unwin, who found the mean crushing pressure of three test blocks, 3 in. along each side, to be 807.7 tons per square foot. He also tested a number of cement blocks with the following results :

Age of block in months.	Mean strength per sq. ft. Tons.
32–36	170.4
28½–29½	161.9
20–23	169.2
8	128.7
5	122.4
2	90.6

The blocks were placed between millboard and lead.

Near each end of the dam a culvert, 15 ft. diameter, was constructed through the dam to carry off the storm water during construction. These culverts have since been built up, an iron pipe 2 ft. 6 in. diameter being introduced and built round solid ; these pipes lead into a valve chamber, and out at the back of the wall, and can be used as storm outlets. The compensation water is drawn from one of these pipes at the west end of the dam, and is fed by an 18-in. pipe into the various gauging chambers after having passed through a specially designed equilibrium valve.

The total length of the aqueduct, from the straining tower in the lake to the Prescot Reservoir, is about 68¾ miles. It consists of a succession of tunnels, and three lines of pipes capable of passing 40,000,000 gallons per day. The tunnels are already made of the full capacity, being 7 ft. diameter, but only one line of pipes will be laid for the present ; the other two lines are to be laid when the auxiliary supplies from the Marchnant and the Cowny are connected by tunnels to the reservoir. The aqueduct commences at the straining tower, with a concrete culvert about 765 yards long, built below the bed of the reservoir ; it then enters the Hirnant Tunnel, 2⅝ miles in length, regulating valves being placed at the inlet. From the outlet the water enters the pipes, 42½ in. diameter, for a distance of about seven miles, the pipes being underground, except when they pass a stream near the village of Llanrhaiadryn-Mochnant, and will discharge the water into the balancing reservoir at Parc Uchaf, the capacity of which is 2,000,000 gallons. The pipes then continue underground for 6½ miles, when they enter the Cynynion Tunnel, 4,620 ft. in length, and passing over the narrow valley of Morda, enter the Llanforda Tunnel, nearly a mile in length, and discharge into the reservoir at Oswestry, which has a capacity of 46,112,000 gallons. The water is then passed through the sand filtration beds and into a clear water reservoir. If necessary, the water can be supplied to Liverpool without passing the filter beds. From the clear water reservoir the water is conveyed in pipes for 17¼ miles underground to Malpas, except at the valley of the Wych Brook, which is crossed by nine arches. In this length the Shropshire Union Canal and two branches of the Great Western Railway are crossed, the operation at the former presenting great difficulties, owing to the yielding nature of the ground. A balancing reservoir is built

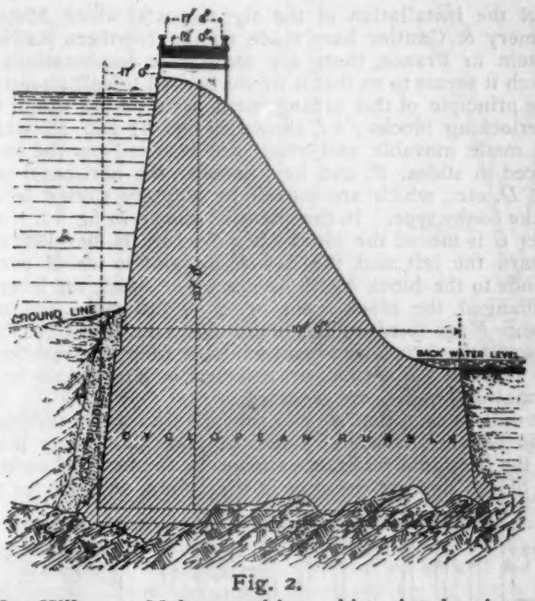


Fig. 2.

at Oat Hill, near Malpas, and from this point the pipes are laid underground for 11⅛ miles to the hill near Cotebrook, upon which is built another balancing reservoir, having a capacity of 2,000,000 gallons. Upon this section two branches of the London & Northwestern Railway are crossed, and the Shropshire Union Canal near Beeston. The pipes then pass underground for 11 miles to Norton, and as the hill at this point is lower than the hydraulic gradient, it has been necessary to build a water-tower. This section crosses the West Cheshire Railway near Delamere, the London & Northwestern Railway at Tatton Weaver, and the River Weaver. The method of crossing the River Weaver is by sinking steel pipes into the bed of the river and covering them with concrete. The tower at Norton is of novel construction and presents several interesting features. The next length of 9½ miles to the existing reservoir at Prescot is a most difficult section, for it passes, wholly underground, the Bridgewater Canal near Norton, the Mersey & Irwell Canal, and the River Mersey three miles above Runcorn ; the Sankey Canal near Fiddler's Ferry, the London & Northwestern Railway and several branches of it, and of the Sheffield & Midland Joint Railway.

The Corporation wished to lay the pipes under the Mersey in the bed of the river, of a sufficient depth underground to be quite beyond the reach of anything which might interfere with the navigation. This plan was strongly objected to by the Conservators of the Mersey and by the Ship Canal Company. After a long trial, the Board of Trade required the pipes to be laid in a tunnel under the bed of the river. This tunnel is constructed of cast-iron rings, 9 ft. internal diameter ; vertical shafts are sunk at each side of the river, 9 ft. internal diameter, forming the tunnel proper, which has a slight fall to the north side of the river for drainage purposes. The cast-iron rings in the tunnel are in short lengths—2 ft. 6 in.—for facility of construction. The water mains under the Weaver and the Mersey are made of steel plates riveted together.

The straining tower at the commencement of the aqueduct is a most interesting structure, and the details of its construction and elaborate apparatus for regulating the

flow, and the cleansing automatically of the filters, have been most carefully designed and worked out, the whole arrangement being entirely novel and ingenious.

RAILROAD SIGNALS IN EUROPE.

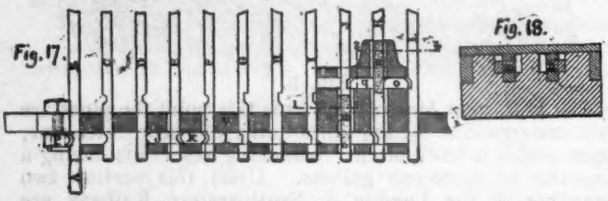
(From the *Revue Generale des Chemins de Fer.*)

(*Continued from page 560.*)

II.—THE REMERY & GAUTIER APPARATUS.

In the installation of the signal posts, which Messrs. Remery & Gautier have made on the Northern Railway system in France, there are some new combinations to which it seems to us that it would be well to call attention. The principle of this arrangement rests on the use of the interlocking blocks *j k l*, shown in figs. 17 and 18, which are made movable and which are bevelled on the ends, placed in slides, *V*, and held between the horizontal bars *B C D*, etc., which are moved by ordinary slotted levers of the Saxby type. In the situation shown in fig. 17, if the lever *G* is moved the block *l* is moved by its bevelled end toward the left and the bar *F*, the slot in which corresponds to the block *k*; if, on the other hand, the lever *E* is changed, the block *k* not being able to move, the bars *D* and *F* are fixed by the blocks *j* and *k*. We have then between the four levers mentioned the following interlocking relation: *F* normal or reversed is interlocked by *D* normal if *B* and *G* are reversed.

It will be seen that we can thus obtain certain combinations between *n* levers, sufficient allowance being made for the frictional resistance shown by the bevelled ends of the blocks against the slots in the levers, and also for the



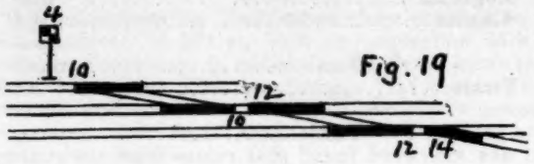
transverse oscillation of the bars, which in principle can only be moved in a longitudinal direction, but which can nevertheless hardly be made to fit perfectly in the slots.

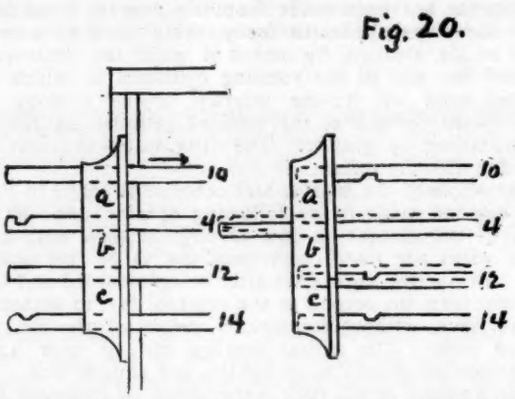
An arrangement of this kind exists at the station of Don-Sainghin on the Lille-Bethune line, where the problem presented was under the following conditions, indicated in fig. 19. A signal 4 controls the starting of the trains, and should interlock with the switches 10, 12, and 14. The most complicated combination presented is that where the departure takes place over the switch 14, because it is then necessary that the signal 4 could only interlock with the switch 14 when 10 and 12 are reversed.

The use of the three blocks *a b c*, fig. 20, permits us to make the following combination: If we reverse 10 the block *a*, moved by its bevelled end, displaces the bar 4. This moves the block *B* into the slot 12, and 14 is only interlocked when 12 has been reversed; then, in order to move the lever 14, it is necessary first to reverse 4, that is to say, to put the signal at *Stop*; the slot in this bar giving play to the block *a*, the bar 14 can be displaced, moving the blocks *c* and *b*, and thus causing the bars 12 and 14 to oscillate.

The case that we have just cited is sufficiently simple, and is that in which the same bar, entering only into a relation of interlocking, need be moved transversely only in one direction. It may happen, for example, that we have at the same time the two relations (figs. 17 and 20): if JR, IN and HR : LN.

In this case *K*, which is not displaced transversely in the first relation, should be rendered movable in the second. The makers have provided for this necessity by placing in mortises made at the end of the bars *J* and *K* pieces *m n* making a lug which fills the space on either side of the bar in such a way as to limit its oscillation. If, in fact, we commence by reversing *K* the end of the piece *n* moves the block *o* in the slot in *L*; but *L* is not interlocked, for if we reverse it *o* returns to its former position, displacing the piece *n*, which moves the block *q*, and this movement is possible only as long as *J* is normal. The same relation exists, on the other hand, between *I*, *J*, and *K*, thanks to the movable piece *m*. It may be seen, without enlarging further, to what a variety of combinations the use of these blocks and sliding pieces will lend itself. The idea is evidently taken from the cam principle used by M. Dujour.

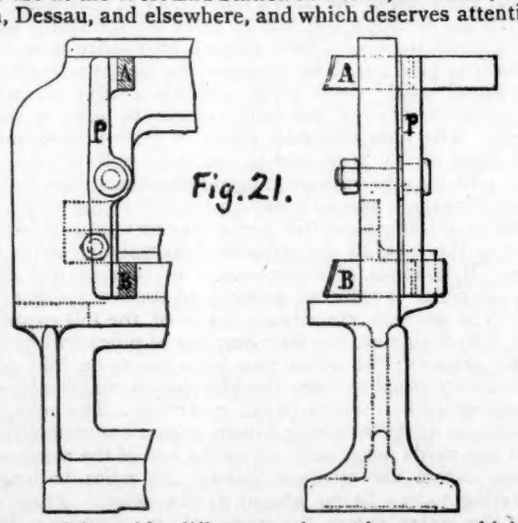




In cases where bars situated above the slotted levers have interlocking relations with other bars situated below them, the communication between the two groups *A B*, fig. 21, is established by a connecting rod *p*, at the ends of which are fixed bevelled blocks, which enter into play with the bars *A* and *B*. The movement of the blocks is then opposite or parallel, according as the bars are placed on the same side or on opposite sides, with relation to the connecting rod.

III.—THE FROITZHEIM SYSTEM.

At the Electrical Exhibition in Vienna in 1883, there was shown an apparatus of the Froitzheim system, which is in use at the West End Station in Berlin, at Cassel, Potsdam, Dessau, and elsewhere, and which deserves attention,



because of its wide differences from the types which we have heretofore described.

It may be used for connections by wires, as well as for rigid connections, and might also be employed in connection with the apparatus of the block system (Hattemer & Kohlfurst) in such a way that, according to the arrangements used in the German stations, we can from the central post situated in the station building lock the levers worked by the signalmen at the outer signal stations.

. We will consider first a central apparatus for four signals and eight switches, the first worked through a double

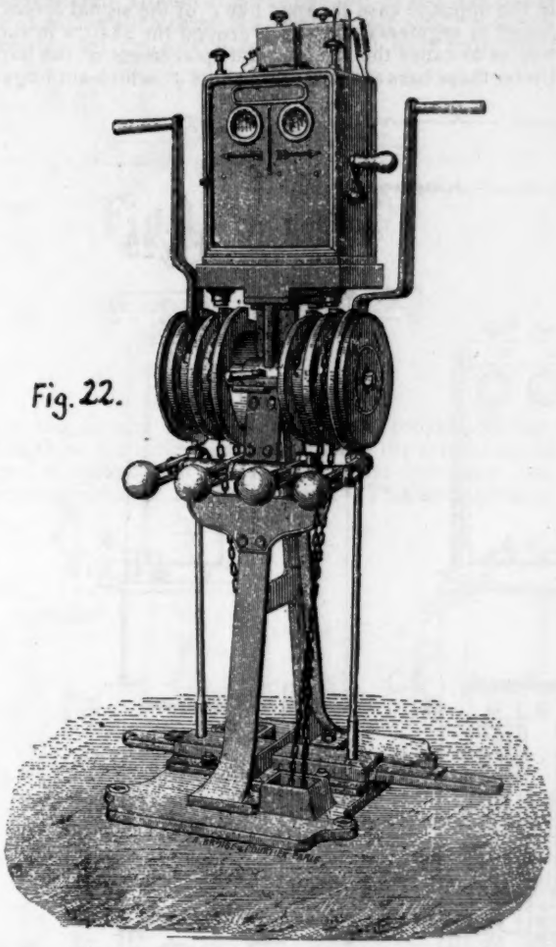


Fig. 22.

wire, the others attached to their levers by rigid connections.

To work the signals it is necessary to make a half revolution of the pulleys *D*, figs. 24 and 25, by means of a handle *A* fixed to the shaft. Chains *n* rolled on these pulleys pass over the bearing pulleys *D'* and transmit the movement of the shaft to the signal. But the rotation of the pulleys *D* can only take place in one direction, when we have first lifted the handle *J* to loosen the ratchet wheel *a'* placed on the circumference of the pulley *D*. By this movement we cause the rods *a* to descend; these through the levers b^1 b^2 b^4 work on horizontal bars, carrying lugs like *c*; in front of these lugs other bars f^2 can be moved in a perpendicular direction and will uncover, in the fixed bars f^1, openings corresponding to these lugs *c*;

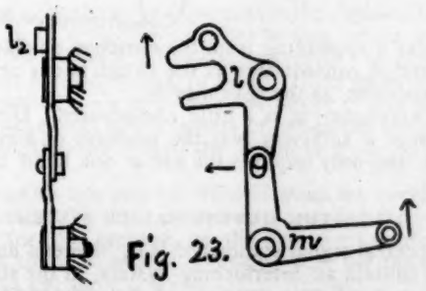


Fig. 23.

the interlocking then takes place and is reciprocal; the movable bars f^2 are displaced by reversing the switch levers *B* (fig. 25) furnished with the points l^1 l^2 on which a slight pressure through the lever *K* suffices to cause the movement of the bars to begin. Above these signal levers is a box *M*, which contains the switches bringing into use the electrical connections, which permit us to control the movement, if the signal has properly followed the working of the lever.

As we see, this type of apparatus can hardly be applied except for simple interlocking combinations. The use of compound interlockings would produce too great a complication; moreover, it will be seen that the working of the signal lever requires the use of two hands, one at the crank, the other at the catch handle.

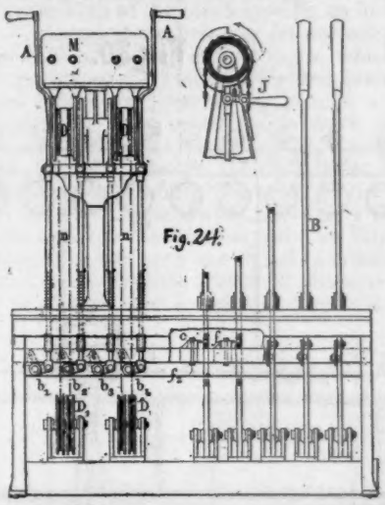


Fig. 24.

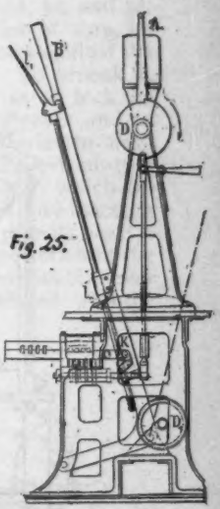


Fig. 25.

Against these smaller inconveniences there may be placed the advantages which this apparatus has, that it may be used in direct connection with the block signals which allow us to stop electrically the working of the signal levers. As may be seen by examining fig. 22, a lock can be attached to the pulleys by which the signals are reversed, and can be so arranged that they will only be set free when the current necessary to draw back the lock has been sent from the central signal station. We will not enlarge further on these details, which belong more to the block than to the interlocking system.

If we consider the signal posts with wire connections, we find that all the levers are worked by pulleys, and the

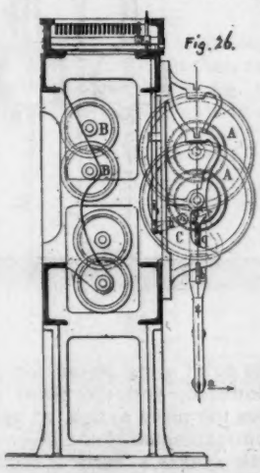


Fig. 26.

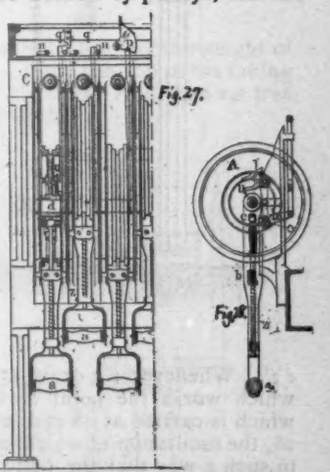


Fig. 27.

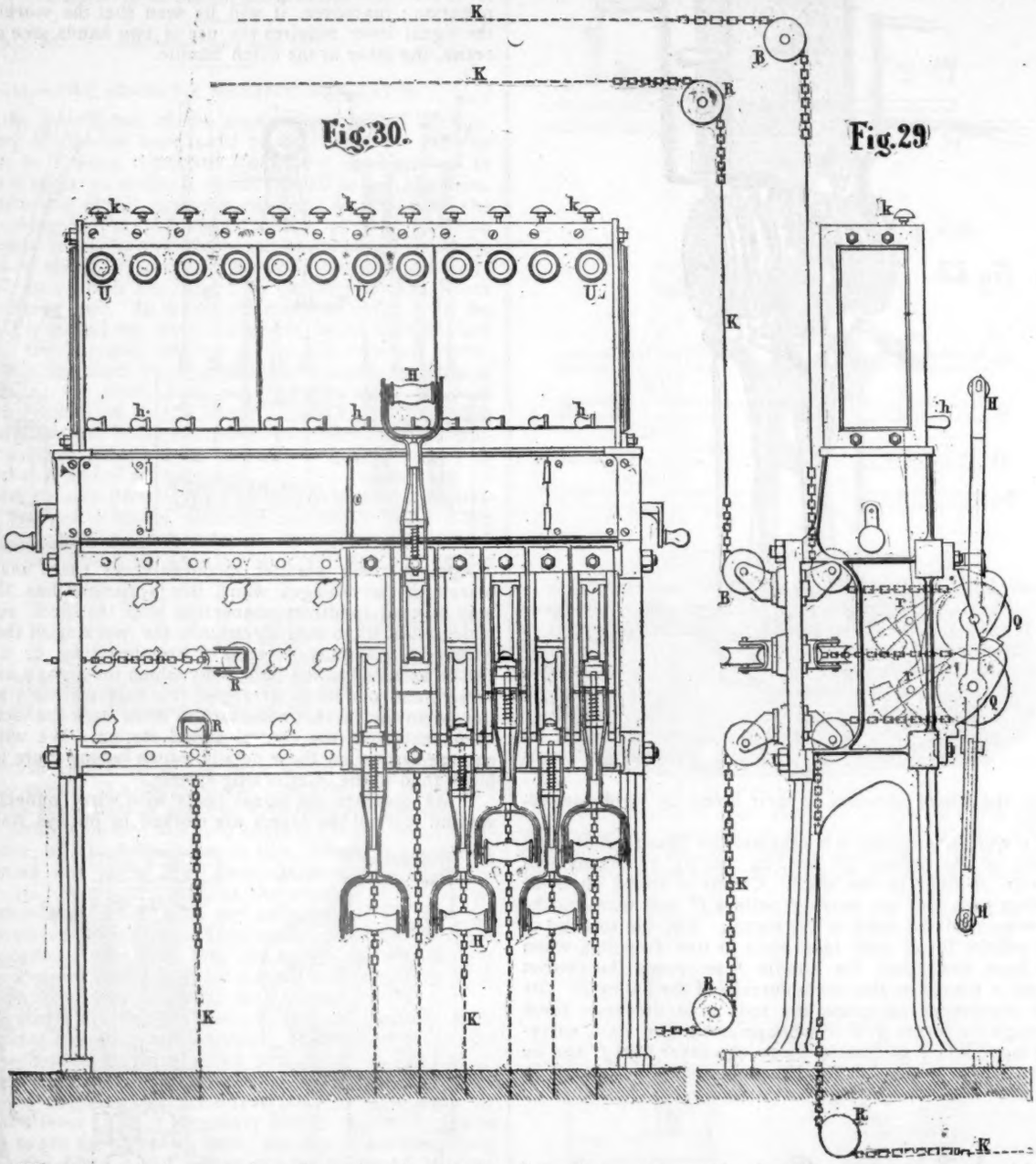
interlocking arrangement shows a disposition altogether different from that which we have described.

On a cast-iron stand *C*, figs. 26 and 27, are mounted vertical pulleys *A* furnished with grooves over which pass the chains connected with the wires by which the signals and switches are worked, and passing over carrying pulleys like *B*. On the shaft *d* of each pulley there is fixed a lever *z*, arranged with a point *a*; to work the apparatus we must cause the corresponding pulley to make half a revolution by raising the lever *z*, as shown in fig. 26; in the normal position these levers *z* are, as shown in the cut, thrown down. Their extreme positions are fixed by the

stops *d*, which at the lower end of their course engage in slots made in the stand *C*. By moving the point *a* vertically we disengage the lug from the slot, and the lever can then be reversed if it is not otherwise interlocked.

The interlocking table, situated on the upper part of the apparatus, connects with the levers through bell-cranks

Below each of the rods $i\ i^1$ of a switch lever are found pieces which make a quarter turn when the rod is raised. In the opposite case the rods like i^2 of the signal levers are joined to segments p, moving around the shaft u in such a way as to cause the horizontal displacement of the bars q. Under these bars are mounted others q^1, which abut against



$i\ i^1$. Whenever we draw at the point *a* the piston-rod *q*, which works the point *b*, is lowered, and the point *e*, which is carried at its end, moves the piece *u*, figs. 27 and 28, the oscillation of which is communicated to the lever *h* in such a way that the bell-crank *i* takes a vertical oscillating movement, which causes the necessary interlocking. Grooves l^3 permit the slide of the fingers with which the piece *u* is provided.

The signal levers have only a single connection *h* placed on one side of the pulley *A*, the switch levers have a second connection similar to the first and placed on the other side; the first acts in the normal position, and the other in the reversed position of the switch. In this last case the piece u^1 acts on the vertical bar *I* through the jointed lever *l m*, fig. 23, which is arranged in such a manner that if i^1, corresponding to the normal position, is raised, *i*, which corresponds to the reversed position, is lowered, and *vice versa*.

the pieces *n* depending from the switches, or placed below them, and in consequence fix the switch in one or the other of its positions, as the case may be.

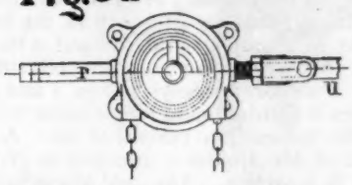
This arrangement is a little complicated; nevertheless, it solves in a sufficient way the problem of simple interlocking, and only requires the use of one hand by the signalman.

IV.—THE SIEMENS-HALSKE SYSTEM.

The central signal stations of MM. Siemens and Halske did not contain an interlocking system, in the strict sense of the word; they are stations of the ordinary type of the block system, arranged to interlock some switches with signals, the levers of which are made immovable by induction currents, sent out from a signal station, which is always placed close to the office of the station-master. But this interlocking is not done in the cabin of the signalman, for the reason that in Germany it is not usual to con-

centrate the working at a distance from the switches; by orders of the general administration the levers of these remain scattered around the station, and at the end of the lever of each switch there is a locking bolt which makes it impossible for the switch to be opened by a switchman

Fig. 31.



unless the signals have been put in the proper position; and as these are locked electrically from the central signal station, it follows that the station-master indirectly controls the position of all the switches. This arrangement, prescribed by the regulations of the German railroads, has been made with the intention of placing on one person the concentrated responsibility for the movement of the signal, while keeping others specially employed to work the switches. We will not find, then, in the description of this system, combinations springing from the necessity of concentrating in a single signal cabin a great number of apparatus for the purpose of effecting various movements; but as the Siemens apparatus has as yet never been fully described, it will be of interest to give an account of an installation made under these conditions. The station which we take as an illustration is that of Callau, on the line from Berlin to Gorlitz.

Figs. 29 and 30 show the apparatus in the signal cabin; the levers are all of a type very similar to that which we have just described, under the Froitzheim system; to give them a movement of 180 degrees, in raising them from below to a vertical position, we must turn the pulley Q and give the wire K a movement which lowers or raises the wing of the semaphores, through which the signal is given to the engineers.

These signals can only be changed when the corresponding switches are in their proper positions for the passage of trains; for that purpose, on the line of transmission of the signal, there is placed a locking-bolt for the switch, as shown in fig. 30.

On the inside of a cast-iron case is a pulley p, which can turn around on a vertical axis, and is furnished below with a small lug e. When the switch is in proper position this lug fits into a slot made on the bar r, depending from w to the switch rail. When the switch rails are not fully in contact, or when the position of the switch is changed, this slot is not opposite the lug, and the pulley is fixed; the signal which remains at *Stop* can then be changed. If the switch has two positions (that is, if it is what we call a three-throw switch) it is sufficient to make two slots in the bar r, and then the signal is only locked at *Stop* when the switch rails are in the proper position.

We will not compare this rudimentary method of locking with the improved arrangements which we have already described, but will pass at once to the description of the interlocking between the levers. To understand this arrangement, it is necessary to show a plan of the ordinary interlocking of the block system, as in figs. 32, 33, and 34.

The semaphore being in its normal position of stop, its lever H is interlocked by a lug u, which bears against the extremity of the counterweighted lever r. To unlock it, and throw the lever H up in such a way as to lock the semaphore, it is necessary to work an indicator and to cause alternate currents to pass through the electro-magnet T; the armature then oscillates, and its extremity S releases successively the teeth of the sector J, which besides its use for showing alternately the red and black, is also used to unlock the signal; for this purpose its shaft x is hollow, but when the signal falls under the action in the oscillations of S the hollow of this axle x permits the lever a to escape; the end of this lever c is connected with the piston-rod s; this is drawn down by the counterweight of the lever r, and can then raise itself, the apparatus taking the position shown in fig. 32; the lever H is then set free and the semaphore can be changed.

Fig. 32.

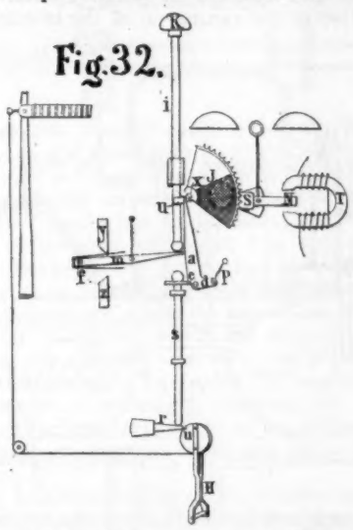


Fig. 33.

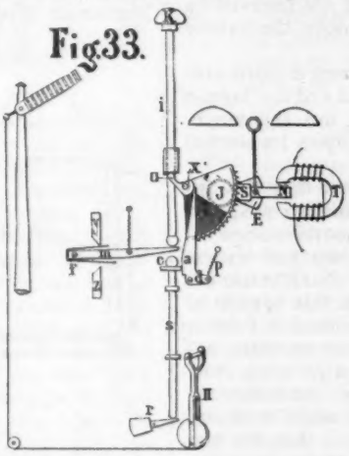


Fig. 34.

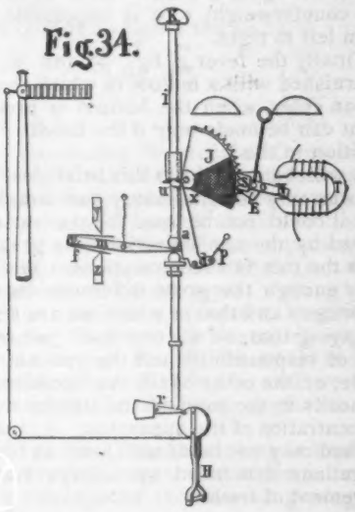


Fig. 35.

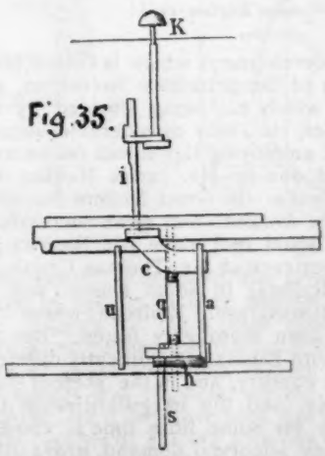
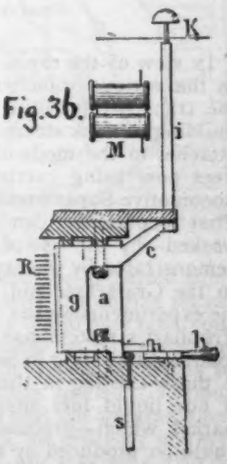


Fig. 36.



When the signal has been put back at *Stop*, it is again locked by pressing on the button K, which causes the lever r to descend into the slot u.

If now we look back at figs. 29 and 30 we will see that each signal lever H has corresponding to it a handle h, which the signalman can use from left to right and *vice*

versa. Figs. 35, 36, and 37 show how these handles are in connection with the buttons *K* and the rods *s*.

Each of these handles, as shown in fig. 37, works a lever with three arms *g*; the branch *z* moves horizontally toward the right or left one of the bars *R*. The branch *y* causes the lugs *n* to enter into slots made on the bars depending from other signals; from this it follows that the handles *h* are interlocked with each other; the lever *g*

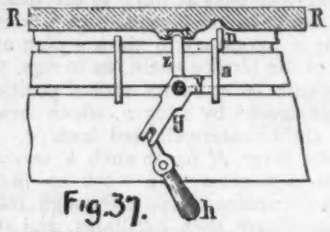


Fig. 37.

acts on a rod *s*, which commands the counterweighted lever *r*, which is similar to that used to lock or unlock the direct movement of the signals. When the handle *h* is passed from left to right it causes the rod *s* to descend and to lock the lever of the signal by means of an inclined plane situated on the lower end of the lever *g*. Inversely, when the signal is at *Line Clear* as the rod *s* is relieved by the counterweight *r*, it is impossible to move the handle from left to right.

Finally the lever *g*, figs. 35 and 36, carries a third arm *c* furnished with a hollow in which the rod *i* of the button *K* can enter, when the bottom is pressed, but this movement can be made only if the handle *h* occupies its normal position to the left.

It will be seen from this brief description that this apparatus only permits binary and simple interlockings, and that it could not be used for the varied combinations required by the concentration of a great number of levers, as is the rule in French stations. We can characterize exactly enough the great difference between this system of movement and that to which we are accustomed in France by saying that, on the one hand, we seek the decentralization of responsibility and the concentration of apparatus, while, on the other hand, the intention is to centralize the authority in the hand of the station-master while avoiding concentration of the apparatus. It is possible that this last method may not be as well fitted as the other for the quick operations demanded by a large traffic and a constant movement of trains.

(TO BE CONTINUED.)

LIQUID FUEL ON LOCOMOTIVES.

(From the London *Engineering*.)

In view of the rapid development which is taking place in the various branches of the petroleum industries, and the transport facilities which are being afforded by the building of tank steamers, etc., very considerable interest attaches to the mode of employing liquid fuel on locomotives now being carried out by Mr. James Holden, the Locomotive Superintendent of the Great Eastern Railway. That locomotives can be worked—and most successfully worked—by the use of liquid fuel alone has been amply demonstrated by the experience of Mr. Thomas Urquhart, on the Grazi-Tsaritsin Railway in South Russia, and by the experiments on the Pennsylvania Railroad, where Mr. Urquhart's system has been thoroughly tested. But the conditions existing in South Russia are eminently different to those existing in this country, and in the present state of our liquid fuel supply, and the irregularities in the market which—probably for some little time to come—would be produced by any abnormal demand, grave difficulties exist in the employment of such fuel on any English railroad in the exclusive manner in which it is so successfully used by Mr. Urquhart.

These and other practical difficulties have been thoroughly appreciated by Mr. Holden, who has met them in a thoroughly common-sense way. In place of altering any of his engines to use liquid fuel burners exclusively, he has been contented—for the present, at all events—to use the liquid fuel as an auxiliary to, and not as an entire substitute for coal, and while making provision for replacing a large proportion of coal by liquid fuel, he has left the engines fitted with his apparatus fully available at any moment to work with coal alone if desired. In fact, the change from using coal and liquid fuel in combination to coal alone can be—and has been—made in the middle of a run without inconvenience.

The arrangements which Mr. Holden has devised for burning the liquid fuel are very simple, and will be readily understood from the annexed engravings. From these it will be seen that the ordinary fire-grate and fire-brick arch are left unaltered, the only alteration in the fire-box being the insertion of a couple of tubes about 6 in. in diameter through the rear water-space, one on each side below the level of the fire-door, as shown in figs. 1 and 2. To each of these tubes is fitted a liquid fuel injector combined with a ring-jet for inducing a current of air. A perspective view of one of Mr. Holden's injectors is given in fig. 3, while fig. 4 is a section. The best proportions for these injectors and the best disposition of the accompanying ring-jet have, of course, been arrived at after a considerable amount of experimenting, but the arrangement itself is extremely simple and answers its purpose admirably. The steam is supplied to the central jet of the injector, on

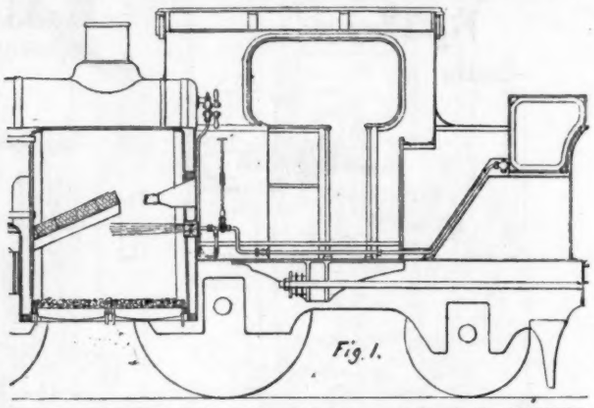


Fig. 1.

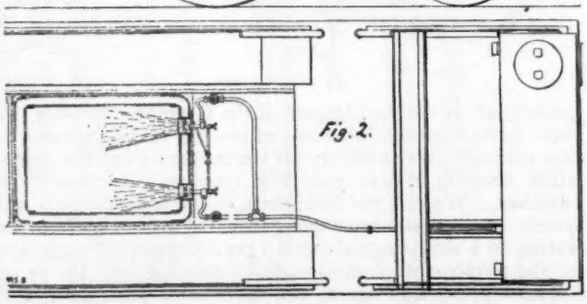


Fig. 2.

issuing from which it meets the annular stream of liquid fuel, which is supplied to the injector through the branch shown, the mixed steam and spray being discharged through several openings in the flattened nozzle (see fig. 3). The steam is supplied direct from the boiler without any superheating.

The ring-jet surrounds the front part of the injector as shown; by its means a strong induced current of air is formed and directed upon the issuing jet. One cock regulates the steam supply to both injectors; this cock, together with two others controlling the ring-jets, and another which is used as a warming cock when necessary for heating the liquid fuel in the tank, being neatly combined in one fitting, mounted on the back of the fire-box, and connected by an internal pipe to the dome. The warming pipe above mentioned is only used in very cold weather when burning tar or very heavy oils. The liquid fuel flows to the injectors by gravity, the tank containing it being sufficiently elevated; the supply is regulated by a separate cock to each injector. Provision is also made for blowing steam through all the oil pipes, etc., and, in fact, the whole of the arrangements are worked out in a thoroughly practical way.

In working on Mr. Holden's system a thin coal fire is kept on the grate, and to assist in keeping the grate properly covered with a very thin fire, lumps of chalk are placed on the grate when starting work for the day. The ash-pan dampers are kept very nearly closed, nearly the whole of the air required for supporting combustion entering either

Fig. 3.

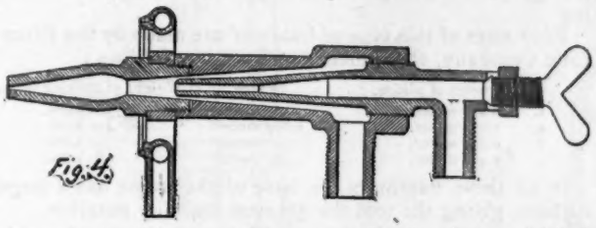


Fig. 4.

through the injector tubes or at the fire-door, which is kept open and fitted with an internal deflector just as when coal alone is being burned. It is found that when burning the liquid fuel an exceedingly soft blast is required, and the blast nozzle has to be materially larger than usual. Thus in the case of engine No. 193, of which we shall speak presently, and which has cylinders 17 in. in diameter by 24-in. stroke, the blast nozzle has been enlarged to 6 in. in diameter, while the smoke-box has also been fitted with air valves, by which air can be admitted near the base of the chimney and the exhaustion due to the blast thus diminished. To enable the engine to be used as a coal-burner, if necessary, however, the blast pipe is fitted with a supplementary nozzle of the ordinary size, which by means of an external lever can be at once brought into position.

The first experiments of Mr. Holden on liquid fuel burning were made at the Stratford Works of the Great Eastern Railway Company on a boiler in the department where Pintsch's oil gas is manufactured for lighting trains. At these gas works one of the products is a tar which it is difficult to dispose of at any price, but this is now burned under the boiler, which was fitted with the liquid fuel apparatus early in 1886. The boiler is a small one of the Cornish multitubular type, 10 ft. long by 4 ft. in diameter, with a furnace 7 ft. long by 3 ft. in diameter, from which 122 iron tubes 1¾ in. in diameter by 3 ft. long extend to the back of the boiler. The boiler is worked at 60 lbs. pressure, and when coal was used the consumption per week (79 hours in steam) averaged 68 cwt. 1 qr. 16 lbs., or 97.1 lbs. per hour. With the liquid fuel apparatus the consumption per week, with 69 hours in steam, has averaged 454½ gallons of tar and 2 cwt. of coal, or an average per hour of 65.9 lbs. of tar and 3.4 lbs. of coal.

The arrangement was next applied to three boilers of the locomotive type in the wagon department at Stratford, and on these its performance has been very satisfactory. The boilers are worked at 80 lbs. pressure, and the comparative results of a week's working with coal only and with coal and liquid fuel in combination have been as follows:

With coal (Staveley) only, the consumption for 63½ hours' work, including lighting up, was 156 cwt., or 275.1 lbs. per hour. With the coal and oil in combination there were used in 60½ hours' work (including lighting up) 55 cwt. of Staveley coal and 546 gallons of green oil, or an average of 101.8 lbs. of coal and 99.3 lbs. of oil (= 9 gallons) per hour. With coal only the evaporation was at the rate of 7.16 lbs. of water per pound of coal, while with the coal and oil it was 8.91 lbs. per pound of the combined fuels.

Subsequently the system was applied to a furnace in the steam hammer shop, a rivet furnace in the boiler shop, a Cornish boiler in the printing department, a six-coupled tank locomotive used for shunting purposes, and a four-coupled tank passenger locomotive (No. 193).

In the case of the printing-office boiler just mentioned the apparatus is fitted as shown in fig. 5 annexed, and a comparison of the cost of working with coal only in 1887, and with coal and liquid fuel during the present year (the comparison being made for a week in each case), gives the following results:

Coal only Used.—1887. Consumption during one week from August 15 to 20 (inclusive), 74½ hours' work, including lighting up = 80½ cwt. = 121.3 lbs. per hour.

Cost for 100 hours = 12,130 lbs. of coal at $2.64 per ton = $14.31.

Coal, Coke, and Tar—"*Holden's System.*"—1888. Consumption during one week from June 25 to 30 (inclusive), 87¾ hours' working, including lighting up

= coal 15 cwt.	= 19.2 lbs.	per hour.
= coke 11½ "	= 14.7 "	"
Gas tar 280 galls.	= 35.1 "	"
Total.....	69 lbs.	per hour.

Cost for 100 hours

= 1,920 lbs. of coal at	$2.64	per ton	= $2.27.
= 1,470 " " "	2.28	"	= 1.47.
= 3,510 " " "	3.00	"	= 4.70.
Total.....			$8.44

The passenger tank locomotive No. 193, which we have mentioned above as being fitted with the liquid fuel apparatus, has, as we have already stated, cylinders 17 in. in diameter with 24-in. stroke, and coupled wheels 5 ft. 4 in. in diameter, and since it was fitted with the apparatus in March, 1887, it has been running most successfully, working heavy suburban trains of 15 carriages, making frequent stops, while it has also been employed taking main line passenger, averaging about 10 carriages, on longer runs. Through the courtesy of Mr. Holden we have had an opportunity of traveling on this engine, and we can testify to the ease with which the liquid fuel apparatus can be managed.

With the liquid fuel it is found that the steam is kept up more easily and steadily than when coal alone is used, while the liquid fuel gives especial facilities for getting up

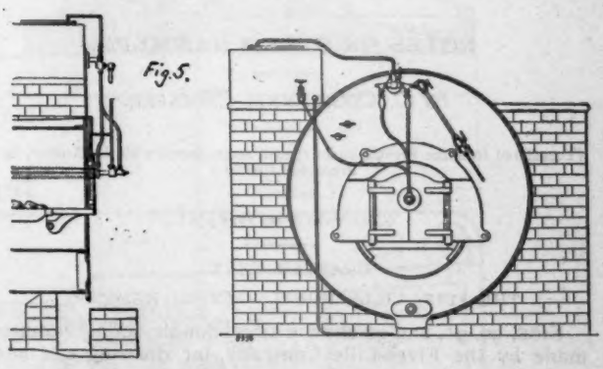


Fig. 5.

steam rapidly if required, the pressure being raised from 50 lbs. to 140 lbs. in nine minutes with the engine standing. Engine No. 193 is fitted with a liquid fuel tank containing 210 gallons, and this quantity will, as a rule, last for a run of about 200 miles, varying of course according to the weight and character of the train hauled. Various kinds of liquid fuel have been used, and the apparatus appears capable of dealing with any of the ordinary marketable qualities. On the occasion of our making a trip on the engine there was being burned a mixture of one-third "green" oil with two-thirds tar, and this was burned entirely without smoke or trouble of any kind. Roughly speaking, the consumption of fuel on the engine above referred to is one gallon (or 11 lbs.) of liquid fuel (a mixture of two-thirds ordinary gas tar and one-third creosote or

furnace oil) to about 14 lbs. of coal per mile. We subjoin particulars of a comparative trial of this engine and a sister engine, No. 194, employed in working the same trains, No. 193 burning coal and liquid fuel in combination, and No. 194 coal only. Radford coal was used in both cases. The trial commenced July 12, and concluded July 20, 1888, each engine having worked six days. The following statement shows miles run, quantity and cost of fuel, etc., consumed by each engine during that period :

Engine.	Miles run.	Fuel used, pounds.				Cost.
		Coal.	Liquid fuel.	Chalk.	Total.	
193	951¾	13,511	10,505	784	24,800	$33.99
194	951¾	27,738	.....	...	27,738	44.33

Results per Mile.

	Fuel used, pounds.				Cost.	Per cent. of liquid fuel and chalk to coal used.
	Coal.	Liquid fuel.	Chalk.	Total.		
193	14.2	11.0	0.8	26.0	3.58 cts.	83 per cent.
194	29.1	....	...	29.1	4.65 "	.....

Cost of coal, per ton (2,240 lbs.), $3.58 ; liquid fuel, per gallon (11 lbs.), $1.25 ; chalk, per ton, $1.32.

It will be seen from the facts we have stated above, that Mr. Holden's system of using liquid fuel is one of very great promise, and it appears to us of especial value for use in cases where it is of importance to be able to at once revert to burning coal alone, as may occur in consequence of fluctuations in the market price of oil or other circumstances. In the case of railroads, for instance, it is an especial convenience that an engine fitted up for burning liquid fuel can at any time be run with coal alone in the event of its having to work in a district where a store of liquid fuel has not been established. In the case of war-vessels also the use of liquid fuel as an addition to coal appears to have many practical advantages not at present attendant on the use of liquid fuel alone. We believe it is intended to extend the application of the system on the Great Eastern Railway, and we hope in due course to be able to place before our readers a further account of the results obtained.

NOTES ON STEAM HAMMERS.

By C. Chomienne, Engineer.

(Translated from the French, under special arrangement with the Author, by Frederick Hobart.)

(*Continued from page* 550.)

CHAPTER XXVI.

THE FIVES-LILLE DOUBLE-ACTING HAMMER.

Figs. 90, 91, and 92 show a small double-acting hammer made by the Fives-Lille Company, for drawing out and for ordinary shop forgings.

This hammer is of a very simple design, and its parts are few ; steam is admitted to the steam-chest by a flat horizontal valve, and the distribution is made by a circular balanced valve. The levers by which both are operated are close to the hand of the hammerman.

The piston, which is shown in fig. 90 in the cover of the cylinder, takes the place of the arm usually placed on the axis of the working lever to limit the stroke of the piston. This arm was worked by the movement of the lower part of the piston-rod, and it was found that one inconvenience of the arrangement was that it was apt to give the hammerman a pretty forcible blow if he allowed the piston to move too long.

Steam acts upon the upper surface of this additional piston, being carried there through a pipe which is connected with the steam pipe of the hammer. When the piston is allowed to rise too high it closes the steam port in the upper end of the cylinder, and there is then a cushion of compressed steam between its upper face and the lower face of the additional or safety piston, and consequently the latter receives a slight movement upward, which in its turn is limited by the compression of the steam between its upper surface and the cylinder head, the small valve of the latter being closed by the first movement of the safety piston ; an equilibrium is very quickly established between these two pressures, and the upward movement of the hammer is thus arrested without shock.

This hammer is not automatic ; it is worked by hand, and with full stroke can give about 60 blows a minute. If, on the other hand, a shorter stroke is used, giving a light blow, it can be run up as high as 120 to 150 blows per minute.

The piston-rod has two flat surfaces made one on each side, which, with the long stuffing-boxes used, secures perfect guidance, and prevents the hammer-head from turning.

Four sizes of this type of hammer are made by the Fives-Lille Company, the dimensions being as follows :

	Diameter of piston.	Stroke.	Weight of striking mass.
1.	0.280 meter.	0.535 meter.	300 kilos.
2.	0.330 meter.	0.600 meter.	450 kilos.
3.	0.360 meter.	0.700 meter.	590 kilos.
4.	0.400 meter.	0.850 meter.	980 kilos.

In all these hammers the base of the frame has a large surface, giving the tool the greatest stability possible.

CHAPTER XXVII.

THE MULHOUSE DOUBLE-ACTING HAMMER.

Figs. 93, 94, and 95 show a small double-acting hammer built by the Société Alsacienne at Mulhouse, fig. 93 being a front view, fig. 94 a section, and fig. 95 a plan. The diameter of the steam cylinder is 0.300 meter, and the maximum stroke of the piston is 0.850 meter.

The admission of steam into the steam-chest is given by a valve worked by a lever placed conveniently to the hammerman. The distribution of steam is through a circular balanced valve, consisting of two pistons of bronze, which work in a cylinder, also of bronze, furnished with openings for the admission and exhaust of steam. These pistons have no packing ; they are loose and work easily in the cylinder.

If the hammer arrives near the upper end of its stroke before steam has acted on the upper part of the piston to cause it to descend, it strikes a lever connecting with the valve-rod, thus throwing up the lever and admitting steam at once to the upper end of the cylinder.

The water of condensation is carried off by a small pipe which is connected with the bottom of the steam-chest, and which carries off this water to the ground.

The piston is of iron, and is forged in one piece with the rod ; it is provided with three packing rings of steel. The piston-rod is of circular section, and as in the hammer described above, there are two flat surfaces made on it, as shown in figs. 94 and 95, which prevent it from turning, and which also serve in connection with the stuffing-box as guides. The lower part of the piston is slightly conical and enters the hammer-block, which is simply shrunk on, no further attachment being found necessary.

The hammer is of wrought iron, its face being hardened and tempered. The anvil is made in the same way, and is fixed by a dovetail to a block of cast steel, which rests upon a large base in the foundation.

The total weight of this tool is about 10 tons. The base rests on a separate foundation upon a bed of oak timbers, held together by bolts. This bed in its turn is placed on a mass of beton or concrete, the thickness and size of which vary according to the nature of the soil.

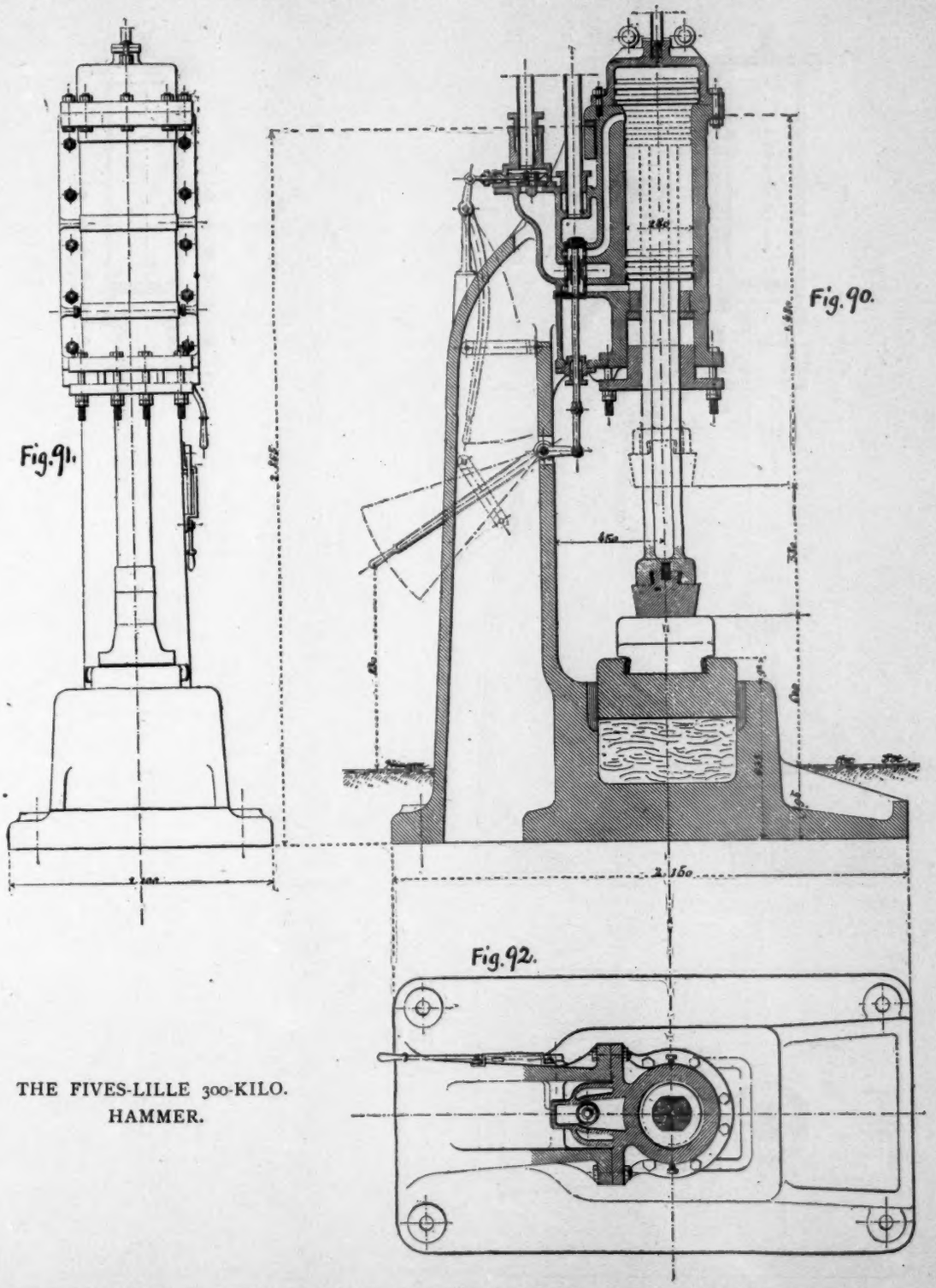
This hammer works by hand, and is not automatic. It is very convenient for forging pieces of moderate dimensions, as, for instance, the material used in the construction of locomotives. The force of the blow can be regulated at will according to the effect which it is desired to produce.

A small hammer of this or a similar class is now almost indispensable in a machine shop of any size.

CHAPTER XXVIII.

BEMENT, MILES & COMPANY'S DOUBLE-ACTING HAMMER.

Figs. 96, 97, 98, and 99 show a double-acting hammer built by Bement, Miles & Company, Philadelphia, fig. 96 being an elevation, fig. 97 a front view, and fig. 98 a plan.



THE FIVES-LILLE 300-KILO. HAMMER.

It approaches somewhat in general form and arrangements to the Massey hammer. The diameter of the steam cylinder is 200 mm., and the maximum stroke of piston is 560 mm.

Steam reaches the steam-chest through a throttle-valve worked through a lever by the hammerman, and the distribution of steam is made by a circular balanced valve of cast iron, which moves in a brass sleeve or bushing, having steam and exhaust ports.

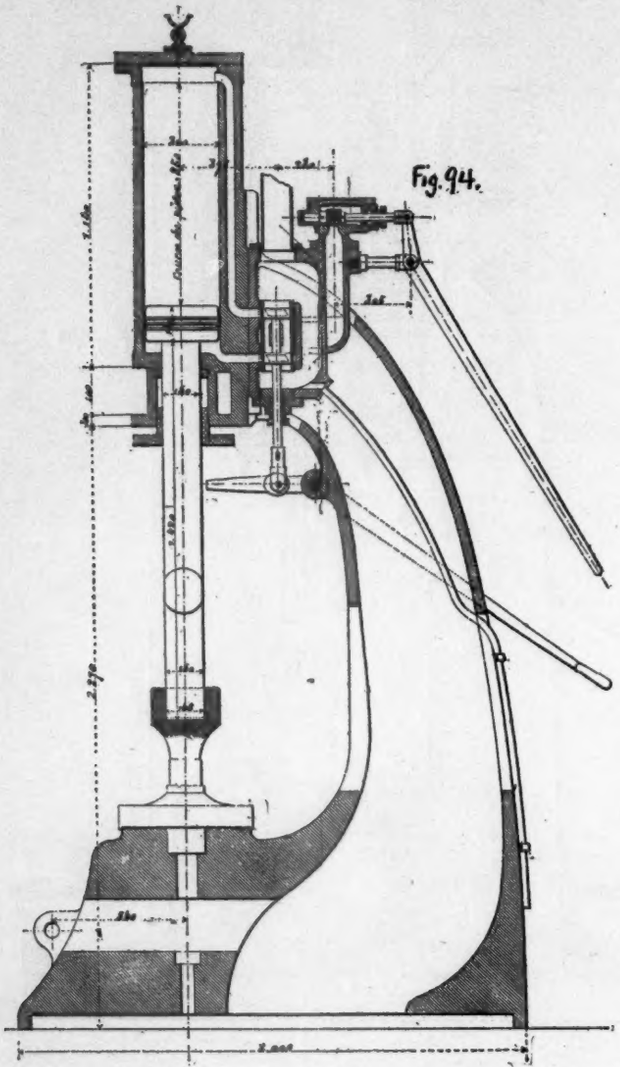
This hammer can work automatically or by hand; the automatic movement is obtained by a lever with two arms, one of which by means of a bell-crank works the valve-rod, while the other receives its movement through an inclined plane made on the back face of the hammer, in order not to disturb the hammerman. This inclined plane is formed of a bar of steel which can be changed at will. If it is desired to work the hammer by hand, all that is necessary is to detach this bar. Above the cylinder and on the center line of the hammer are two springs, the object of which is to take up the shock in case the piston should be allowed

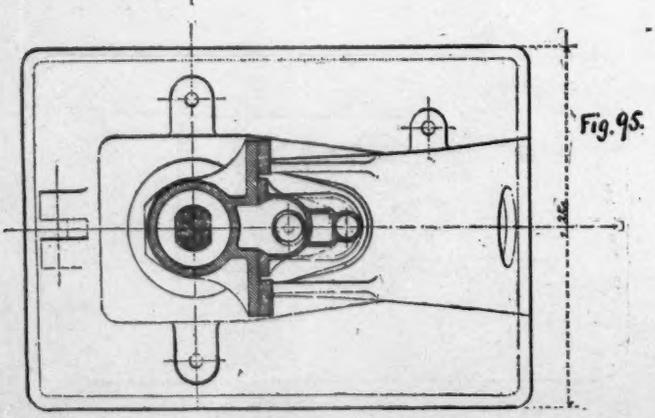
to rise too high. These springs are shown on a larger scale in fig. 99.

The hammer is either of wrought iron or of steel. Its center line is at an angle with that of the frame, in order to give more room for drawing out or forging. The hammer is guided by cast-iron V-shaped slides, which are fastened to the frame by bolts in such a way that they can be replaced at will. These slides carry on each side keys by which the wear can be taken up.

The anvil-block is centered in the frame, and is fastened by four keys which prevent any rotary movement.

This hammer, which is of simple construction, is an excellent tool for forging light pieces.



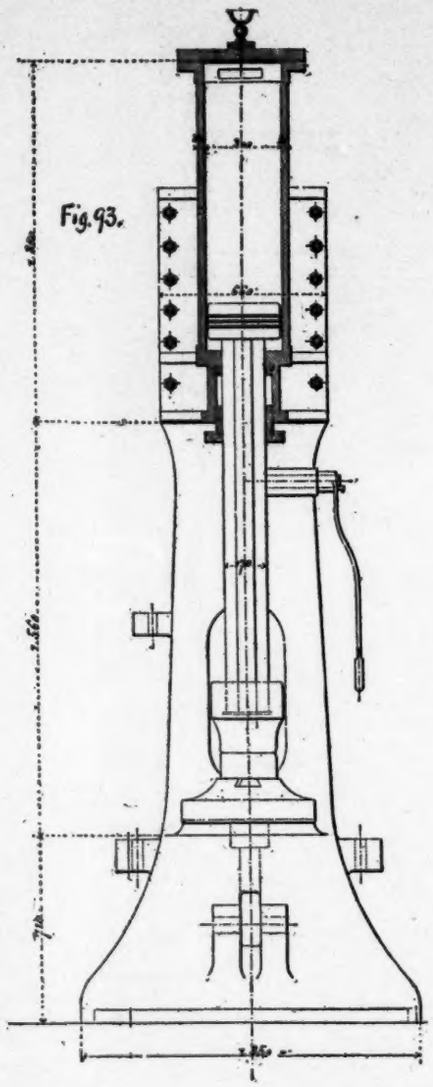


CHAPTER XXIX.

THE BANNING DOUBLE-ACTING HAMMER.

Figs. 100, 101, 102, and 103 show a small double-acting hammer built by M. Banning at Hamm, in Westphalia. It consists of a frame of cast iron fixed upon the anvil-block by means of bolts and keys. The anvil-block has a circular base of considerable dimension, and carries a series of bosses provided with holes which permit the passage of spikes or bolts, which fix the base on a bed of timbers, which, in its turn, rests on a mass of masonry.

The cast-iron frame carries steel guides which direct the motion of the hammer and prevent any rotary movement.



THE MULHOUSE 300-KILO. HAMMER.

The hammer, the piston-rod, and the piston are of steel, forged in one piece.

This hammer is especially intended to draw out iron and steel bars. The distribution of steam is made by a lever; consequently the stroke of the hammer can be varied according to the thickness of the piece to be forged. Steam reaches the steam-chest through a small valve which is worked by the machinist.

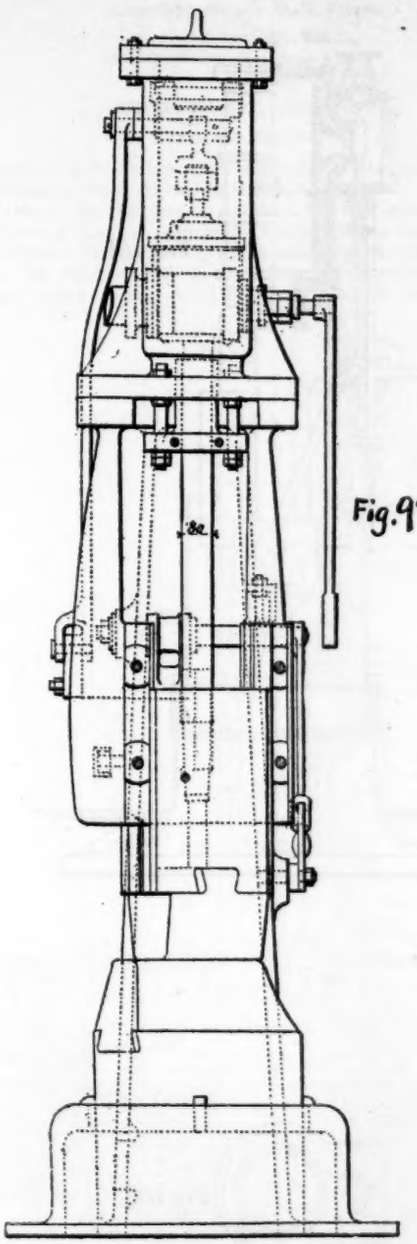


Fig. 97.

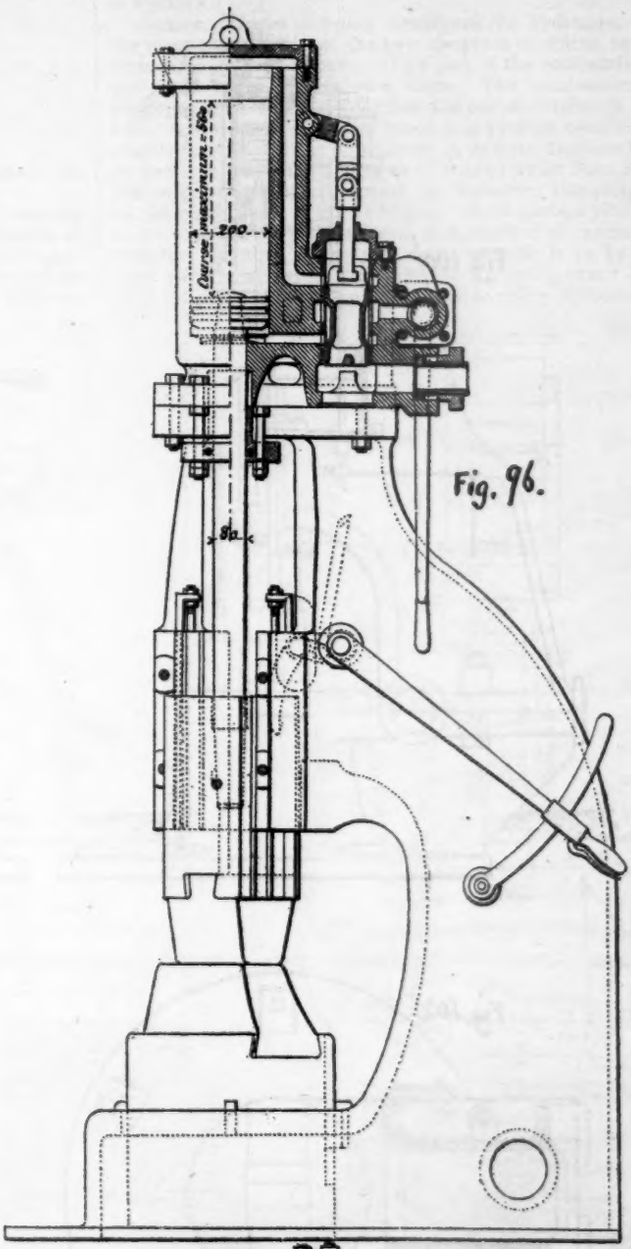


Fig. 96.

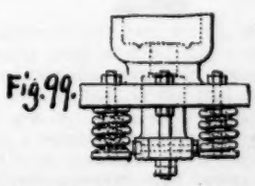


Fig. 99.

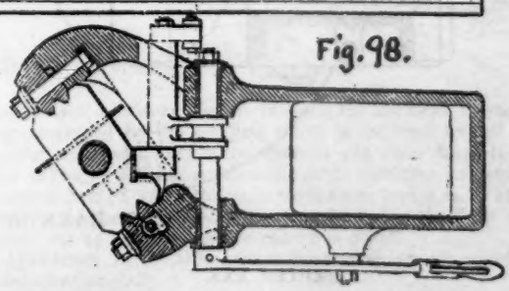


Fig. 98.

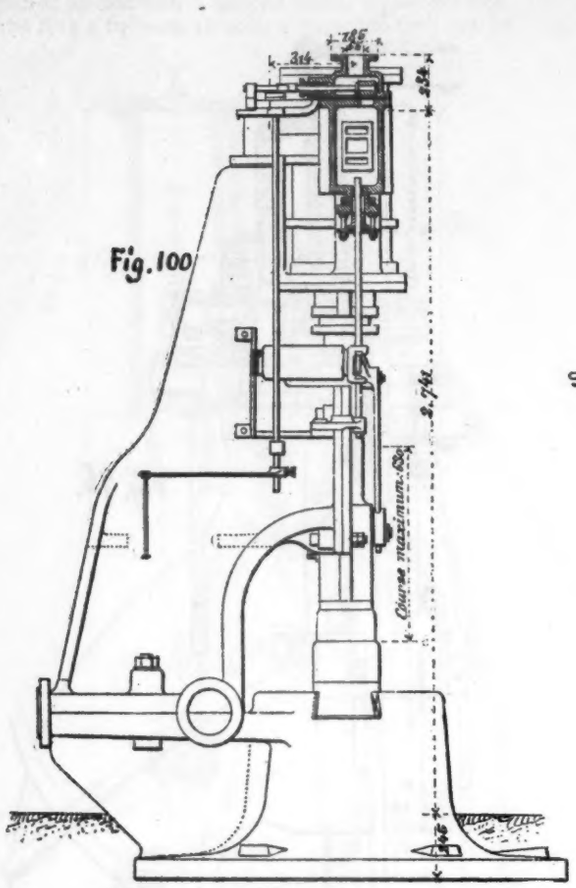
THE BEMENT 360-KILO. HAMMER.

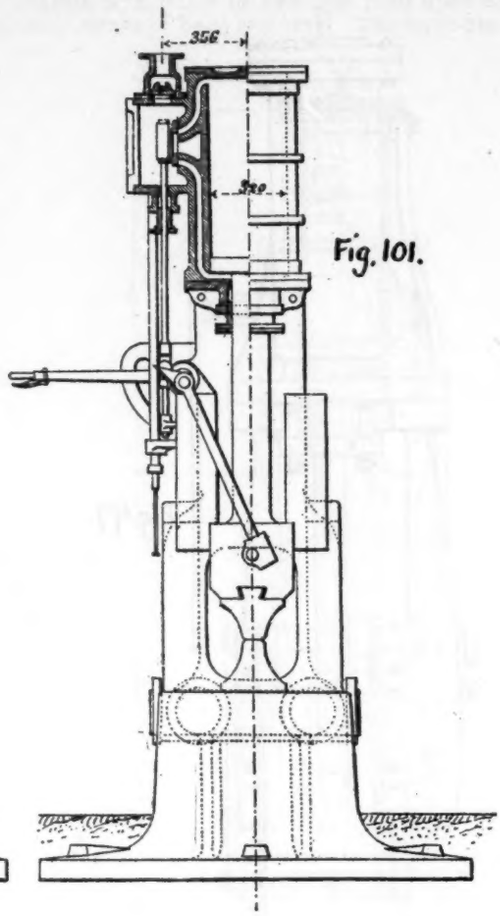
flat D-shaped valve. The hammer works directly one arm of a lever, the other end of which acts upon the valve-rod. The upper part of this lever is fixed eccentrically on a small shaft which can also be worked through a hand

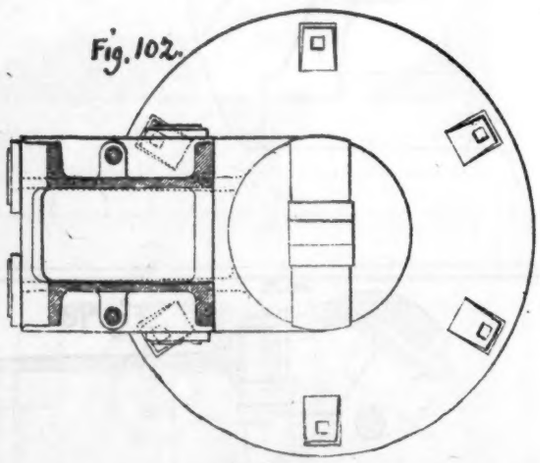
The diameter of the steam cylinder is 320 mm., and the maximum stroke of the hammer is 630 mm. When this type of hammer is intended to make ordinary forgings the automatic motion and the flat valve are replaced by a cir-

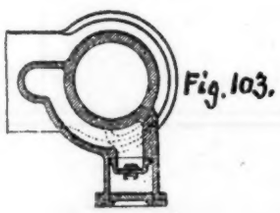
cular balanced valve, and the hammer is worked by hand.

This type of hammer, which has a force varying from 50 to 1,000 kilos., is always double-acting, and in most cases is worked automatically and at high speed.









THE BANNING 400-KILO. HAMMER.

CHAPTER XXX.

THE THWAITES DOUBLE-ACTING HAMMER.

This hammer, shown in figs. 104 and 105, has an independent anvil-block, and its foundations are made with much care. The lower part of the piston-rod carries an arm which works a lever, thus rendering the hammer automatic. If it is preferred to work the hammer by hand, it is sufficient to detach this arm. Steam reaches the steam-chest through a valve which can be opened or closed at will by the hammerman, and the distribution is made through a circular balanced valve. The two levers are so placed that they can be readily worked by the hammerman, and the small escape valve intended to relieve the cylinder from the water of condensation is also so placed that he can readily reach it.

The diameter of the piston is 355 mm., and its stroke 676 mm. The weight of the striking parts is 600 kilos.

The shaft on which the valve lever works carries at one end an arm which is put in motion by the lower part of the piston-rod, thus serving to limit the stroke.

(TO BE CONTINUED.)

CATECHISM OF THE LOCOMOTIVE.

(Revised and enlarged.)

By M. N. Forney.

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(Continued from page 566.)

CHAPTER XXI. *(Continued.)*

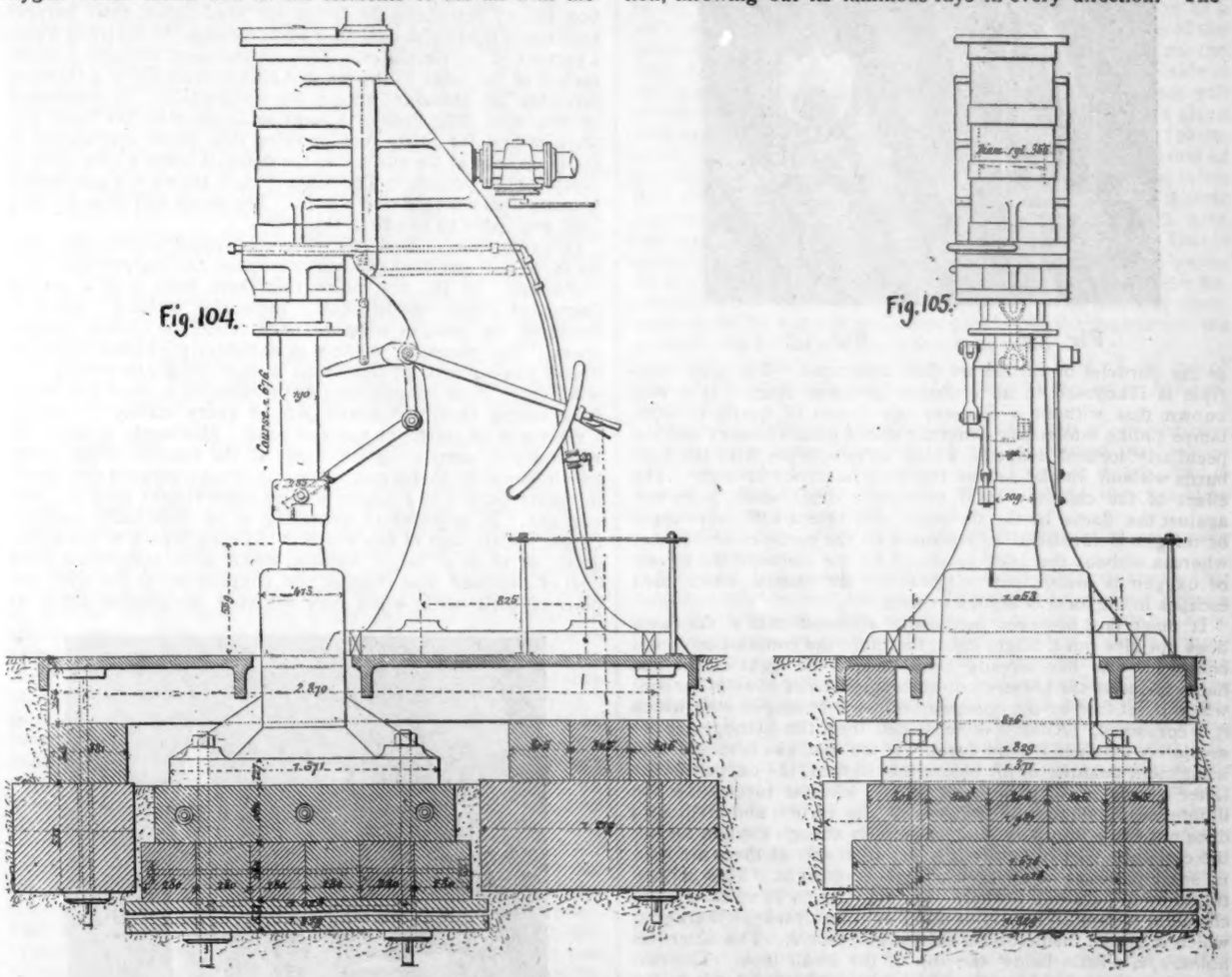
COMBUSTION.

QUESTION 556. *How can the process of the combustion of the gas generated from the coal be best explained?*

Answer. As this gas is substantially the same as ordinary illuminating gas, the manner in which it burns can, perhaps, be made clearer by examining the combustion of an ordinary gas-light. As stated before, combustion is a chemical union of the oxygen which forms one of the elements of the air with the chemical union is the circumstance that the heat generated during the combination is sufficient to maintain an igniting temperature, and the necessity of doing so in order to continue the process is of very great importance in the combustion of coal in locomotive boilers, as will be shown hereafter.

QUESTION 557. *How does an ordinary gas-light burn after it is lighted?*

Answer. Under ordinary conditions the hydrogen, which is the most combustible of the two elements of which coal gas is formed, is the first to burn. This part of the combustion forms the lower bluish part of the flame. The combustion of the hydrogen thus separates it from the carbon, which is then set free; and as carbon is never found in a gaseous condition when uncombined with other substances, it at once assumes the form of fine soot when the hydrogen is burned away from it. This fine soot, or pulverized carbon, is, however, intensely heated by the combustion of the hydrogen. Now carbon when heated to an igniting temperature will, if brought into contact with a sufficient quantity of oxygen, combine with it or be burned. Each particle of carbon thus becomes a glowing centre of radiation, throwing out its luminous rays in every direction. The



THE THWAITES 600-KILO. HAMMER.

hydrogen and carbon of the fuel, which, in this case, form gas. It should be clearly kept in mind that combustion is the result of this union, and that the oxygen is as essential to combustion as coal or gas, and, in fact, is the fuel of combustion just as much as coal or gas is. If we were to conduct a pipe from the external air into a vessel filled with coal gas we could *light the air* and it would burn in the gas as the gas burns in the air.

It will be noticed, however, that before either the gas or the air will burn, they must be lighted. Air and gas, even if mixed together in the same vessel, will not burn unless they are lighted. This can be done by the flame of any burning material, or with a piece of metal heated to a very high temperature, or by an electric spark. In other words it may be said that the atoms of the two gases must be excited into activity by the application of heat, that is, what is called an *igniting temperature* must be communicated to them before chemical combination will begin. The chief feature which distinguishes combustion from other sparks last, however, but an instant, for the next moment they are consumed by the oxygen which is aroused to full activity by the heat, and only a transparent gas rises from the flame. But the same process continues; other particles succeed, which become heated and ignited in their turn, and it is to this combustion of the solid particles of carbon that the light which is given out by a gas-burner or candle is due.*

QUESTION 558. *Why does a gas-burner, candle or other flame sometimes smoke?*

Answer. Because the supply of oxygen is then insufficient to consume the particles of solid carbon which are set free and which then assume the form of soot. This can be illustrated if we cut a hole in a card, *d d*, fig. 336, so as to fit over an ordinary gas-burner *b*. If we then light the gas and place a glass chimney, *a a*, over the burner and let it rest on the card, it will be

* "The New Chemistry," by J. P. Cooke, Jr.

found that the flame will at once begin to smoke, because very little air can then come in contact with the flame, and therefore when the fine particles of carbon are set free by the combustion of the hydrogen, instead of being burned, as they would be if the air with its supply of oxygen were not excluded from the flame by the chimney, they escape unconsumed in the form of fine black powder or soot. If we raise the chimney up from the card, as shown in fig. 337, so as to leave enough space between them at the bottom of the chimney to permit air to enter so as to supply the flame with oxygen, the smoke will instantly cease

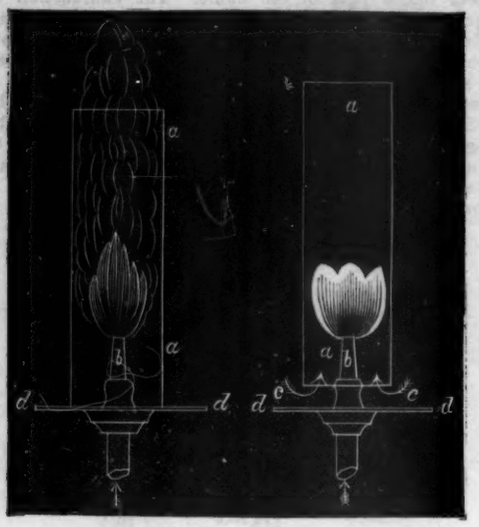


Fig. 336.

Fig. 337.

as the particles of carbon are then consumed. The same principle is illustrated in an ordinary kerosene lamp. It is well known that without a chimney the flames of nearly all such lamps smoke intolerably, whereas with a glass chimney and the peculiarly formed deflector which surrounds the wick the light burns without smoke unless the wick is turned up high. The effect of the chimney is to produce a draft which is thrown against the flame bv the deflector, and thus a sufficient supply of oxygen is furnished to consume all the particles of carbon, whereas without the draft produced by the chimney the supply of oxygen is insufficient to ignite all the carbon, which then escapes in the form of smoke or soot.

It must not, however, be hastily assumed that if the flame does not give out a bright light, therefore the combustion is not complete. As has already been stated, the light of the gas flame is due to the presence of burning particles of solid carbon, which is set free by the combustion of the hydrogen with which it is combined. After it is separated from the hydrogen it immediately assumes a solid form. If the coal gas is mixed with a sufficient quantity of air before it is burned, the oxygen in the latter will be in such intimate contact with the former that the difference of affinity of oxygen for the carbon and hydrogen does not come into play, and as there is enough oxygen for all, the carbon is burned before it is set free, and as there are then no solid particles in the flame, there is no light. This is illustrated by a "Bunsen burner," fig. 338, which is much used in chemical laboratories. It consists of a small tube or burner *a*, which is placed inside of another larger tube *b*. The latter has holes, *c*, *c*, a little below the top of the small tube. The current of gas escaping from the small tube produces what is called an *induced current* of air in the large tube. This air enters through the holes *c*, *c*, and is mixed with the gas in the tube *b*, and the mixture is burned at *d*. The flame from such a burner gives hardly any light, but the heat is intense, as is shown if a metal wire is held in it for a few seconds, as it will very soon glow with heat.

QUESTION 559. *What important difference is there in the structure of the flame of a Bunsen burner and that of an ordinary gas-burner or candle?*

Answer. The gas which escapes from the mouth *d* of the pipe *b*, fig. 338, is mixed with air, and therefore contains within itself the elements which only need to combine to produce combustion; whereas with an ordinary gas-burner or candle the air comes in contact with the flame only from the outside, or on its surface. This is shown better, perhaps, in the flame of an ordinary candle. The heat of such a flame distills a gas from the melted tallow, which is similar in nature to that which escapes from coal at a high temperature. Now by observing the candle very closely it will be seen that at the bottom, close to the wick, there is very little combustion, as the gas there first escapes from the wick and is not heated to a sufficiently high temperature to burn freely. A little above the lowermost part the flame is of a pale bluish color, which is due to the combustion of the hydrogen. Above that, where the carbon is set free, its particles glow with heat imparted by the burning hydrogen and are then consumed by uniting with the oxygen of the air. The combustion occurs only at the surface of the flame, the inside being a mass of combustible gas which cannot burn until it in turn comes in contact with the oxygen of the air. This can be proved by inserting one end of a small tube, fig. 339 (a pipe stem will do), which is open at both ends, into the flame. The combustible gas will then escape at the other end and can easily be lighted with a match.

It will be found that the flame from the Bunsen burner is much more intense than that of an ordinary candle or gas-burner. The reason of this is that combustion, as already stated, takes place through the whole mass of its flame, whereas an ordinary flame burns only at its surface. Common gas-jets are therefore arranged so that the flames will be flat, thus exposing as much surface to the air as possible, and, as explained in answer to Question 496, in describing the lamps for head-lights, their burners are usually made with a circular wick, through the centre of which a current of air circulates. This arrangement exposes a larger surface of the flame to the air, and also with the aid of a chimney furnishes an abundant supply for combustion. In stationary boilers, with long flues of a large sectional area, the flame will often extend for thirty feet, showing that while combustion is going on only at the surface of the flame, it takes a long time to complete the process. The same thing is shown if a gas-burner is made with a single round hole. The flame will then be very long and liable to smoke at the top.

QUESTION 560. *From the preceding considerations what may we infer to be necessary in order to consume coal gas perfectly?*

Answer. In the first place, that there must exist a certain degree of what chemists call "molecular activity," which is produced by heat, or what we have called the *igniting temperature*. The necessity of this is sufficiently obvious with ordinary gas-burners, as they must always be *lighted* before they will burn. Now imagine that it was required to burn gas which was issuing from a hundred jets, of every variety of size, in a violent wind storm, or gusts of wind. Obviously it would be necessary to keep a lighted torch all the time to relight those which would be blown out. The gas in a locomotive fire-box is in reality burned in a storm of wind more violent than any natural one. It is therefore necessary to be constantly ready to relight the streams of gas which the faintest breath would extinguish, or those of larger volume which have absorbed a great deal of heat and thus reduced the temperature at the time and place of their birth, when they assumed the gaseous form, as

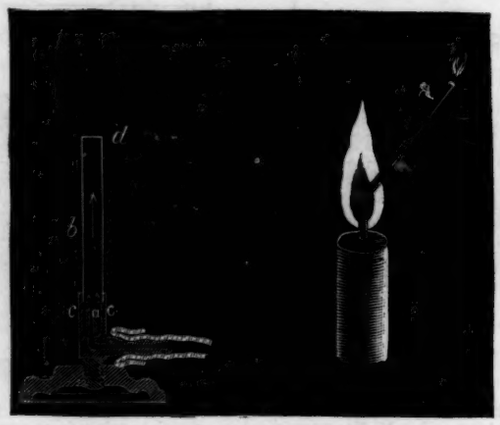


Fig. 338.

Fig. 339.

was explained in answer to Question 554. To relight them with certainty it is necessary to keep a constant temperature in the fire-box high enough to ignite the gas which escapes or is distilled from the coal.

Second. That the chemical change in combustion consists simply in the union of the elements burned with the oxygen of the air; and, therefore, to burn the gas perfectly, without smoke or waste, *enough* air must be furnished to supply all the oxygen which will combine with the fuel.

Third. That the air must be mixed with the gas, otherwise combustion will occur only at the surface of the flame, and will therefore be so slow that much of the gas will escape unconsumed.

It must be clearly kept in mind that no one or two of these

requirements alone, without the third, will burn coal perfectly. What is needed is all three in combination. A very common error is to suppose that passing smoke over a hot fire, or, in other words, maintaining an igniting temperature, will alone effect perfect combustion; or that if a sufficient supply of air is admitted, without an igniting temperature in the fire-box, the fuel will be burned completely. Neither of them will accomplish the object alone, and the gas and air must at the same time be thoroughly mixed with the burning gas in the fire-box.

QUESTION 561. *What substances are produced by the combustion of coal gas?*

Answer. The hydrogen of coal gas unites during combustion with oxygen in the proportion, as indicated by their chemical equivalents, of 1 part by weight of hydrogen with 8 parts of oxygen, the product of which is water. Of course at the high temperature at which the gases combine or burn the water is produced in the form of steam. That water or steam is one of the products of combustion is shown every cold evening, when the insides of shop show-windows are covered with moisture, which is due to the steam that is given off by the burning gas-lights or lamps inside, and is then condensed against the cold glass.

Carbon combines with oxygen in two proportions: first, 6 parts of the former will unite with 8 of the latter, forming what is called *carbonic oxide;* or, 6 parts of carbon will combine with 16 parts of oxygen, forming *carbonic acid gas* or *carbonic dioxide, carbonic anhydride*, as it is called in some of the new books on chemistry. It is probable that the former compound, that is, carbonic oxide, is never or very rarely formed in the flame of coal gas; but, as will be seen hereafter, is a very common and wasteful product of the combustion of the solid portion of the coal which is left after the gas is expelled from it. When there is not enough oxygen for the perfect combustion of the carbon in the flame, it smokes, and the carbon escapes in the form of soot. This, as will be shown, may in a locomotive fire-box help to form carbonic oxide after it leaves the flame.

QUESTION 562. *What remains in the coal after all the gas is expelled by heat?*

Answer. What remains is ordinarily called coke, which, with the exception of some incombustible substances, such as sand, ashes, and cinders, which the coal contains, is nearly pure carbon.

QUESTION 563. *What is the chemical process of the combustion of coke?*

Answer. The solid carbon of the coke when raised to an igniting temperature; or, in other words, on being lighted, unites with the oxygen in one of the two proportions already given; that is, if the supply of oxygen is sufficient, 6 parts of the carbon of the coke unite with 16 parts of oxygen, forming carbonic acid gas, or carbonic dioxide. If, however, the layer of fuel on the grates is thick, or the supply of air is comparatively small, there will not be enough oxygen to supply 16 parts of the latter to each 6 parts of the carbon, so that when that occurs, instead of combining in that proportion, and thus forming carbonic dioxide, 8 parts of oxygen will unite with 6 parts of carbon and form carbonic oxide. Now it should be carefully kept in mind that the heat of combustion is due to the union, or, as it is sometimes expressed, it is the clashing together of the molecules of the two elements which unite. If, therefore, only half the quantity of oxygen unites with 6 parts of carbon, evidently there will be less heat evolved than there would be if twice that amount of oxygen combined with the carbon. From carefully made experiments it was found that the total heat of the combustion of one pound of carbon when converted into *carbonic oxide* was 4,400 units, whereas when it was converted into *carbonic dioxide* 14,500 units were given out. It will thus be seen that it is extremely wasteful to burn coal without a sufficient supply of air to produce carbonic dioxide. The danger of waste from this cause is also increased by the fact that carbonic oxide is colorless and odorless, and therefore its production is not apparent, especially as most persons have the impression that when there is no smoke from a fire combustion is then complete. It burns with a blue or yellowish flame when air is admitted into the fire-box, and its presence can often be detected by these phenomena when the furnace door is opened.

QUESTION 564. *How can the requisite quantity of air be supplied to the fire in a locomotive fire-box?*

Answer. It is done in two ways: one way is to keep but little coal on the grates, or, in the phraseology of firemen, to "carry a light fire." The other method is to admit fresh air above the fire. If the latter plan is adopted when the supply of air through the grates is insufficient for perfect combustion, the carbonic oxide will unite with the oxygen of the air above the fire, and thus a second combustion will take place, the product of which will be carbonic dioxide. It must be kept in mind, however, that not only must there be enough air supplied to the fire to consume the coke, but the gases which are distilled from the coal must also be supplied with oxygen in order to effect their perfect combustion. Even if enough air is admitted to consume the coke perfectly, if the carbonic dioxide thus formed is mixed with large quantities of smoke above the fire, the solid carbon or soot of the smoke may then combine with the dioxide and thus form carbonic oxide, if there is not enough fresh air present to furnish the requisite oxygen for the carbon in the smoke. A very common error is to suppose that smoke can be burned by passing it over or through a very hot fire. The smoke may thus be made invisible, it is true, but it does not therefore follow that it is perfectly consumed.

QUESTION 565. *Is it possible to admit too much air into the fire-box of a locomotive?*

Answer. Yes; probably all the air that is admitted which is not necessary for combustion, or, in other words, the oxygen of which does not combine with the fuel, instead of increasing diminishes the amount of steam which is generated. It does this in two ways: first, by reducing the temperature of the gases in contact with the heating surfaces, and, second, by increasing the volume or quantity of the gases which must pass through the tubes. Heat is transmitted through the heating surface of a boiler in proportion to the *difference* of the temperature of the products of combustion on one side, and the water on the other.* Thus, if the temperature of the water on one side is 250 degrees, and the hot gases on the other is 500, there will be only half as much heat transmitted to the water in a given time as there would be if the gases had a temperature of 750 degrees. If the volume of gases is doubled by the admission of too much air, then obviously in order to pass through the tubes they must move at double the velocity, so that not only is their temperature reduced, but the time they are in contact with the heating surface is diminished in like proportion. This is shown by the effect of opening the furnace door, or of allowing the fire to burn away so that portions of the grate are left uncovered. The volume of cold air which will in either of these cases enter the fire-box will be so great that the pressure of the steam in the boiler will begin to fall at once.

QUESTION 566. *What determines the amount of air which must be admitted to the fire-box of a locomotive to effect perfect combustion?*

Answer. This depends chiefly upon the *rate of combustion*—that is, the number of pounds of coal consumed per hour on each square foot of grate surface. Of course if 100 lbs. is burned it will require twice the supply of air that would be needed if only 50 lbs. were burned.

QUESTION 567. *How should the air be admitted so as to burn the coal perfectly?*

Answer. In burning bituminous coal it has been shown that there are two distinct bodies to be dealt with, the one coke, a *solid*, the other coal gas, which is, of course, a *gaseous body*. The combustion of each of these is necessarily a distinct process. If the requisite quantity of air is supplied to the burning coke, or solid portion of the coal, it will, as has been shown, be converted into carbonic dioxide, and thus be perfectly consumed. If the supply of air is insufficient, the product of the combustion will be carbonic oxide, which is very wasteful. If, for example, there is a thick layer of coke on the grate, the air will enter and unite with the lower layer of coal and form carbonic dioxide, but as it rises there will not be enough air to supply oxygen to the carbon, and another equivalent of the latter will therefore combine with the carbonic dioxide and form carbonic oxide. It is evident, though, that the thinner the fire, the easier it is for air to pass through it, and consequently the greater will be the quantity which will enter the fire-box. Nothing would seem easier, then, than to regulate the thickness of the fire on the grates, so that just the needed amount of air would pass through it. If coke alone was to be burned, undoubtedly very perfect combustion would be (and has been) effected in this way; but if a charge of fresh coal, say 100 lbs., is thrown on the fire, coal gas is very soon generated and escapes into the fire-box. This gas needs an additional amount of air for its combustion. It would seem that this could be supplied by reducing the thickness of the fire still further, so that more air would pass through it than was needed for the combustion of the coke alone. If this was done, then too much air would pass through the coke after the gases had all escaped from the fresh coal and were burned. Besides, the passage of the air would be the most restricted after the fresh charge had been put on the fire, just at the time when the most is needed. This difficulty might be overcome if a constant supply of fresh coal just equal to that consumed were kept on the fire all the time, and the thickness of fuel on the grates was then regulated so as to admit just air enough for the combustion of the coke and also that of the gases, the production of which

* This law is perhaps not absolutely correct, but is near enough for our present illustration.

would then be uniform. An approximation to this method of feeding the fire is, in fact, what is aimed at on most locomotives, and probably the best practical results are produced by that method.

Two difficulties are, however, encountered in this method. In the first place, it is impossible to feed a fire continuously with a shovel. There will be intervals between the charges which are thrown in, so that the supply is not uniform, even if the charges do not consist of more than a portion of a shovelful at a time; and if the fire was fed in this way as uniformly as possible it would then be necessary to open the furnace door every time fresh coal was put on the fire, and so much cold air would thus be admitted that more would be lost by lowering the temperature of the boiler than would be gained by the improved combustion.

Another difficulty also is encountered in this method of burning coal in locomotives. In order to admit enough air through the fire it is necessary to keep the latter so thin on the grates that the violent draft produced by the blast lifts the coal from the grate-bars and carries the lighter particles through the flues unconsumed. It is thus extremely difficult to keep the grate uniformly covered with coal, and if it is not, the air will enter in irregular and rapid streams or masses through the uncovered parts, and at the very time when it should be *there* most restricted. Such a state of things at once bids defiance to all regulation or control, so that it is found almost uniformly that firemen of locomotives keep enough coal on the grates to avoid the danger of "losing their fire," as they express it—that is, having all the burning coal drawn through the tubes by the blast. *Now, on the control of the supply of air depends all that human skill can do in effecting perfect combustion and economy;* and unless the supply of fuel and the quantity on the bars can be regulated, it will be impossible to control the admission of the air.*

Another method of feeding locomotive boilers is to pile up the coal in the back part in a thick layer as shown in fig. 346, and slope it downward toward the front, so that there is a comparatively thin fire in front. The mass piled up at the door becomes converted into coke, and the production of gas from the coal is more gradual and uniform than it is when only a small quantity is thrown in at a time, and therefore a more uniform supply of air is needed for its combustion. But it is apparent that very little air can pass through the thick heap of coal at the back part of the fire-box, and that therefore all, or nearly all the air which enters it must come in through a comparatively small portion of the grate. It will of course be difficult to admit the requisite quantity, for the reasons already stated.

It is therefore apparent that it is practically impossible to admit enough air through the grates to effect a constantly perfect combustion of bituminous coal. It is, consequently, necessary to admit a portion of the air above the fire. When this is done the air thus admitted must be thoroughly mixed with the gases, to effect perfect combustion and in order to be able to enter into chemical combination, or, in other words, to burn, the gases must combine with the air at an igniting temperature. If too much air is admitted, it will reduce the temperature in the fire-box so much that the gases will not ignite; or, if it is admitted in strong currents, the air and the gases will flow side by side like the currents of two streams of water, the one muddy and the other clear, which, as is well known, mingle very slowly. Besides, if a hot stream of gas encounters a strong stream of cold air and comes in contact with it only at its surface, the latter will be cooled down below the igniting temperature; whereas, if the two had been intimately mixed in the right proportion, the whole mixture would have been hot enough to burn. It is therefore of the utmost importance that the air which is admitted above the fire should enter the fire-box in many small jets. None of the openings for its admission should exceed half an inch in diameter. With the violent draft in a locomotive fire-box there is an extremely brief period of time for chemical combination to take place after the gases are expelled from the coal and before they are hurried into the tubes. As the chemical action between the gases and the oxygen can only take place when the two are in intimate contact, too much pains cannot be taken to distribute the currents of admitted air and thus mix them with the combustible gases. In many cases means are adopted to delay the air and the gases in the fire-box so as to give them time for chemical combination or combustion before entering the tubes.

QUESTION 568. *Does any combustion take place after the gases enter the tubes?*

Answer. Very little; as the flames are extinguished soon after they enter.

QUESTION 569. *Why are the flames extinguished in the tubes?*

Answer. They are then in contact with large quantities of incombustible gas and beyond the reach of a supply of air; besides, the temperature of the tubes which are surrounded with water is so low that the flame is soon cooled down below an igniting temperature.

QUESTION 570. *What temperature is necessary to ignite coal gas or produce flame?*

Answer. A temperature considerably hotter than red-hot iron is needed, as can easily be shown by the fact that a gas-light cannot be ignited with a red-hot poker.

QUESTION 571. *Are there any parts of the fire-box where the temperature is probably below the igniting point?*

Answer. Yes; along the sides and ends near the plates, which are covered with water on the opposite side. At these points the coal is usually "dead" or incandescent, as it remains at too low a temperature to burn. For this reason, in some cases a space of from 8 to 12 in. on each side and still more at the ends of the grates is made of solid plates, without any openings, and therefore called "*dead-grates*," so that no cold air can enter at those points. These plates are made sloping downward from the sides toward the center of the fire-box, so that the coal which falls on them and is thus coked can easily be raked toward the middle of the fire. This arrangement of dead plates often improves the combustion and results in greater economy of fuel. The reduction of the area of the openings between the grate-bars can usually be compensated by making the bars narrower or the spaces between them wider.

QUESTION 572. *What should be the condition of the coal when it is put on the fire?*

Answer. It is true of the coal as well as of the gases that the chemical action between it and the oxygen can only take place when the two are in intimate contact, and therefore the rapidity and completeness of combustion and intensity of heat will be increased by increasing the number of points of contact, or by reducing the size of the fuel. The coal should therefore be broken up, but not so small as to fall between the grate-bars or be carried out of the fire-box by the blast.

QUESTION 573. *What amount of air must be admitted to the fire to effect perfect combustion?*

Answer. It was stated that average bituminous coal contains about 80 per cent. carbon, 5 per cent. of hydrogen, and 15 per cent. of other substances. As a large proportion of the latter are incombustible, we will confine ourselves for the present to the consideration of the combustion of the hydrogen and carbon alone.

The hydrogen, as has been explained, unites with oxygen in the proportion by weight of one part of the former to 8 parts of the latter, and the product of this union is water or steam. As 36 parts of air contain only 8 of oxygen, IN ORDER TO BURN THE HYDROGEN IT MUST BE SUPPLIED WITH 36 TIMES ITS WEIGHT OF AIR.

In order to burn the carbon perfectly it must, as has been explained, be converted into carbonic dioxide, which consists of 6 parts of carbon and 16 of oxygen; and as air consists of 28 parts of nitrogen to every 8 of oxygen, we must furnish 72 parts of air to every 6 of carbon, or, in other words, CARBON NEEDS 12 TIMES ITS WEIGHT OF AIR FOR ITS PERFECT COMBUSTION.

Every pound of average bituminous coal therefore requires 1.8 lbs. of air to burn its hydrogen, and 9.6 lbs. for the carbon, or 11.4 for both. As a portion of the other substances of which coal is composed, besides the oxygen and hydrogen, which others have been classed as impurities, are combustible, there will be no material error if we estimate the amount of air required for the combustion of bituminous coal at 12 LBS. PER LB. OF FUEL. As each cubic foot of air weighs 0.08072 lb., 12 lbs. will be equal to

$$\frac{12}{0.08072} = 148.6 \text{ cubic feet of air,}$$

or, for the sake of even figures and a quantity which can easily be remembered, we will say 150 CUBIC FEET OF AIR ARE NEEDED FOR THE COMBUSTION OF EACH POUND OF COAL. This is the theoretical quantity of air which is needed for combustion. Now, unfortunately, the process of combustion in the fire-boxes of locomotives is one in which any very exact combination of the substances which unite is not possible with the appliances which are now employed. If, therefore, we admitted the exact amount of air given above, while some portions of the fire where combustion was not very active might have more air than is needed, other portions would have too little; and if the air is not very thoroughly mixed, the flame and burning coal may be surrounded with the products of combustion, which would exclude the air and thus reduce its effect upon the fire. For this reason, besides the air required to furnish the oxygen necessary for the complete combustion of the fuel, it is also necessary to furnish an additional quantity of air for the *dilution* of the

* The Combustion of Coal, by C. Wye Williams.

gaseous products of combustion, which would otherwise prevent the free access of air to the fuel. The more minute the division and the greater the velocity with which the air rushes among the fuel, the smaller is the additional quantity of air required for dilution. In locomotive boilers, although this quantity has not been exactly ascertained, there is reason to believe that it may on an average be estimated at about *one-half* of the air required for combustion.* We would therefore have as the quantity of air needed for combustion

$$150 + \frac{150}{2} = 225 \text{ cubic feet.}$$

This estimate is roughly made, but it is the nearest approximation at present attainable. It is probable that the supply of air required for dilution varies considerably in different arrangements of the fire-box and for different kinds of fuel, and it is possible that by admitting the air for combustion in small enough jets, and deflecting the currents of smoke and gases so as to cause them to mingle with the air, the quantity required for dilution might be reduced below that indicated by the above calculation. Undoubtedly all the air which is admitted into the fire-box which does not combine with the chemical elements of the fuel lessens the amount of steam generated in the boiler, both with reference to time—that is to say, per minute—and to fuel—that is, per pound of coal consumed. But with the present locomotive boiler it is simply a choice of two evils. If no more air is admitted than theory indicates to be needed for combustion, then, owing to the imperfect means which are usually employed to cause the air and fuel to combine, a portion of the latter will escape unconsumed; and if *more* air is admitted, the temperature of the products of combustion is lowered and their volume increased, the evils of which have already been pointed out. It therefore becomes a matter in which we are obliged to consult experience and determine by experiment what amount of air it is necessary to admit to the fuel to produce the most economical results.

QUESTION 574. *What proportion of the air should be admitted through the grate, and how much above the fire?*

Answer. This, too, is a question which can probably be answered best by consulting experience. The relative quantity of air required above and below the fire depends very much on the nature of the fuel. Coal which "runs together" or cakes very much or has a great deal of clinker in it, doubtless, will need more air above the fire than other coal which is said to be "drier," for the reason that it will be found impossible to admit so much air through the caking coal in the grate as through the other kind. An idea of the relative quantity which should be admitted above and below the fire may be found if we know how much air is needed to burn the solid carbon or coke which is left after the gas is expelled from it, and how much for the gas itself. The gas which is expelled from a pound of coal consists of about 0.05 lb. of hydrogen and 0.15 lb. of carbon. Now, it has been shown that hydrogen requires 36 times its weight of air to burn it perfectly, so that 0.05 lb. would need $0.05 \times 36 = 1.8$ lbs.; and carbon requires 12 times its weight of air, so that for 0.15 lb. of carbon $0.15 \times 12 = 1.8$ lbs. is needed, so that for both 3.6 lbs. of air is required for perfect combustion. As has been shown, 12 lbs. is needed to consume the whole of the fuel, so that 30 per cent. of the whole supply is required for the combustion of the gas alone. If this is diluted in the same proportion as that required for the combustion of the carbon, and it probably should be even more so, we would have 30 per cent. of $225 = 67.5$ cubic feet of air required for the combustion of the gas. It is certain, however, that the solid coke on the grates is not perfectly consumed, or, in other words, converted into carbonic dioxide, especially when the layer of it on the grates is very thick. When this is the case the air coming in contact with the lower layer of coke forms carbonic dioxide, but as it rises through the burning coke another equivalent of carbon unites with the carbonic dioxide, and thus forms carbonic oxide. If, now, enough air is admitted above the fire, this carbonic oxide will combine with it, and, as has been explained before, a second combustion will take place if there is time and opportunity for combination before the gases enter the flues. It is therefore probable that more than 30 per cent. of the whole supply of air should be admitted above the fire. It is at any rate best to provide the means for admitting more, and also appliances for regulating the supply, so that it can be governed as experience may indicate to be best.

QUESTION 575. *Is it not possible by enlarging the grate to admit enough air to the fire to produce perfect combustion?*

Answer. Yes; when no air is admitted above the fire, large grates are found to produce the best combustion. But while it is true that the same amount of heat will be produced by the union of each equivalent of oxygen and fuel, yet if we can force *more* air and fuel to unite in the *same place*, a higher temperature is produced in that place, just as a fire in a blacksmith's forge is hotter because of the forced blast than that in an ordinary stove, or a smelting furnace than a parlor grate. If, then, we can concentrate the draft in the fire of a locomotive, we secure a greater *intensity* of combustion; and when the air is urged against the solid carbon with considerable force, it comes in contact with every point of its surface, and therefore less dilution of the air is needed, and consequently the products of combustion have a higher temperature; and, as has been explained, a larger proportion of the heat is then transferred to the water than if the temperature is lower and the volume greater.

Intensity of combustion also has the effect of maintaining an igniting temperature; whereas, if the same amount of fuel is burned slowly, its heat may not be high enough to ignite the gases as they are produced.

It is desirable, however, to have all the space that is possible in the fire-box, so as to give room for the mixing of the gases; but with a large fire-box and large grate a decided improvement and economy will often result by diminishing the effective area of the grate by covering a part of it with dead-plates, but at the same time making provision for the admission of air above the fire.

QUESTION 576. *What is meant by the "Total Heat of Combustion?"*

Answer. It is the number of units of heat given out by the combustion of a given quantity (usually a pound) of fuel.

QUESTION 577. *How is this determined?*

Answer. The heat given out by the combustion of one lb. of the chemical elements of which coal is composed has been determined by experiment, and from such data, knowing the substances of which fuel is composed, we can determine the amount of heat which would be developed if they were each perfectly consumed. Thus the total heat of combustion of one pound of hydrogen is 62,032 units, and of the same quantity of carbon 14,500 units.* Therefore, if a pound of coal contains 5 per cent. of hydrogen, the heat given out by the combustion of that element will be $62,032 \times 0.05 = 3,101.60$ units, and if it has 80 per cent. of carbon, the combustion of the latter would develop $14,500 \times 0.80 = 11,600$ units, so that the total heat of the combustion of these two elements would be $3,101.6 + 11,600 = 14,701.6$ units. It was shown in answer to Question 62 that it required 1,213.4 units of heat to convert water at zero to steam of 100 lbs. pressure. As steam is usually generated from water at a temperature of about 60 degrees, the total heat required to convert it into steam of 100 lbs. pressure would be $1,213.4 - 60 = 1,153.4$ units. A pound of average bituminous coal, therefore, contains heat enough to convert 12¼ lbs. of water of 60 degrees temperature into steam of 100 lbs. absolute pressure. Ordinarily only about half that amount of water is evaporated in locomotive boilers per pound of fuel.

QUESTION 578. *What are the chief causes of this waste of heat?*

Answer. It is due, *first*, to the waste of unburned fuel in the solid state. This occurs when fuel which is very fine falls through the grates, or is carried through the tubes and out of the chimney in the form of cinders.†

Second, to the waste of unburned fuel in the gaseous or smoky state. The method of preventing this waste by a sufficient supply and proper distribution of air has been explained in the answer to preceding questions.

Third, to the waste or loss of heat in the hot gases which escape up the chimney or smoke-stack. The temperature of the fire in a locomotive fire-box in a state of active combustion is probably from 3,000 to 4,000 degrees. This heat is in part radiated and conducted to the heating surface of the fire-box, and it is found that more water is evaporated by this portion of the heating surface in proportion to its area than by any other in the boiler. The gases when they enter the tubes transmit a portion of their heat to the surfaces with which they are first in contact. The amount of heat thus transmitted, as has been stated, is in proportion to the *difference* in temperature of the gases inside the tubes and that of the water outside. After passing over the part of the tube with which the gases are first in contact, they then arrive at another portion of the tube surface with a diminished temperature, and the rate of conduction is therefore diminished; so that each successive equal portion of the heating surface transmits a less and less quantity of heat, until the hot air at last leaves the heating surface and escapes up the chimney with a certain remaining excess of temperature

* Rankine.

* The experiments which have been made to determine these amounts do not agree exactly, but those given are thought to be the most trustworthy.

† It should be remarked here that some, and perhaps many, of the cinders which are carried out of the chimney are not combustible, but are composed of the same materials that form clinkers on the grate.

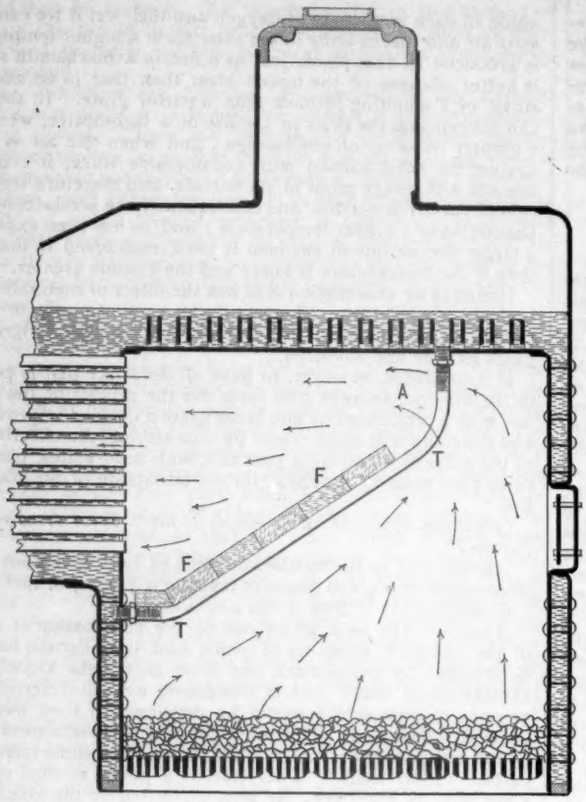


Fig. 340.

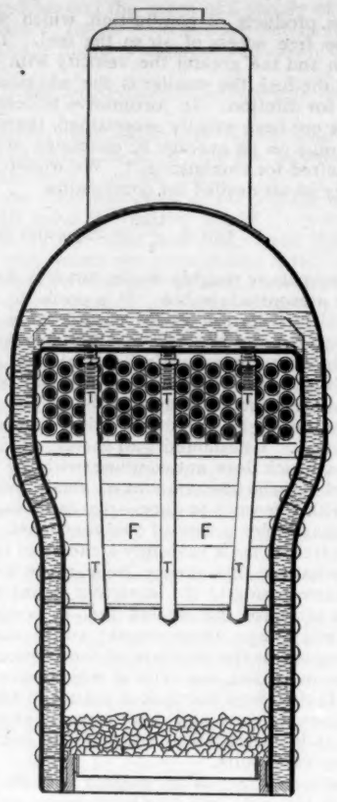


Fig. 341.

Fig. 344.

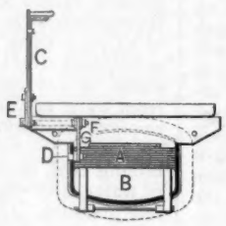


Fig. 345.

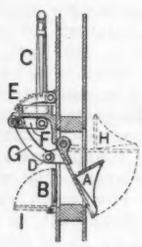
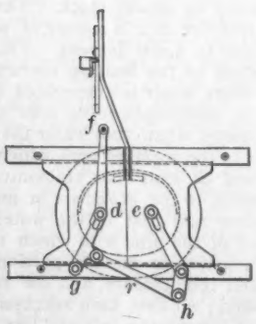


Fig. 343.



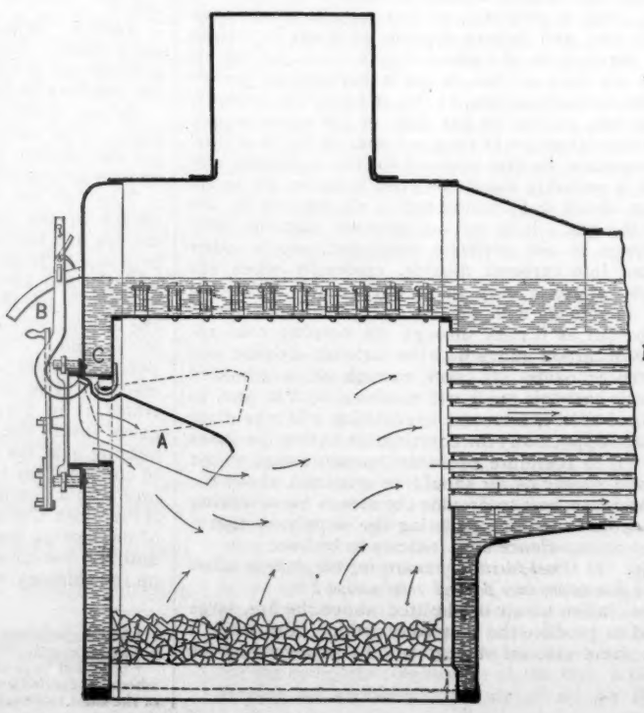


Fig. 342.

above that of the water in the boiler, the heat corresponding to which excess is wasted.* It is, therefore, desirable to extract as much heat as possible from the gases before they escape from the tubes. Now it will be impossible to heat the water outside of the tubes hotter than the gases inside. When the temperature of the water is equal to that of the gases, no more heat will be transmitted from one to the other. If the temperature of the water is 350 degrees, that of the gases in the tubes will never be any lower, but will escape into the smoke-box with not less, but usually considerably more, than that amount of heat. If, however, the cold water is introduced at the front end of the tubes, so that the surface with which the gases are last in contact has a temperature considerably lower than 350, then an additional amount of heat will be transmitted before they escape. It is, therefore, important that the cold feed-water should be admitted near the front end of the boiler, so that the products of combustion will be in contact with the coldest part of the heating surface last, and thus give out as much of their heat as possible before they escape. As a matter of fact, the gases escape at a much higher temperature. Experiments made by the writer showed that the temperature in the smoke-box of a locomotive when first starting was 270 degrees, and when working at its maximum capacity on a steep grade and with a heavy train it was as high as 675 degrees. The average temperature while running was, in three trials on different parts of the road, as follows:

Average steam pressure, 98.8 lbs.; average temperature, 499.8 lbs.
Average steam pressure, 106 lbs.; average temperature, 535.1 lbs.
Average steam pressure, 112.2 lbs.; average temperature, 554 lbs.

In making these experiments a record was made of the indications of a pyrometer and of the steam gauge once every minute while the engine was running. The distance run was 19 miles for the first experiment, 13 for the second and 6 for the third, with 30 loaded freight cars in the train. The last experiment was made while the engine was working on a heavy grade and very nearly up to its maximum capacity.

It will thus be seen that a great deal of heat is wasted by escaping up the chimney.

Fourth, by external radiation from the boiler. This occurs chiefly from the fact that it is not sufficiently well protected or covered with non-conducting material. The practice, or rather the neglect, of not covering the outside of the fire-box with lagging doubtless causes a very considerable loss of heat by radiation and convection from the hot boiler plates.

QUESTION 579. *What is the ordinary form of fire-box employed for burning bituminous coal?*

Answer. It is that represented in plate IV and figs. 90–92, and is simply a rectangular box, and for that reason it is often called a *plain* fire-box. Sometimes provision is made for admitting air into such fire-boxes through hollow or rather tubular stay-bolts, which are put into the sides and front. In most cases, too, the fire-box door has openings for admitting air.

QUESTION 580. *What other appliances are used for burning bituminous coal?*

Answer. The most common appliances which are added to the plain fire-box are what are called *fire-brick arches* or *deflectors*. These are sometimes made of an arched form, and rest on supports on the sides of the fire-box. In other cases the fire-brick, *F F*, figs. 340 and 341, is supported on tubes, *T T*, which are fastened to the front end of the fire-box and into the crown-sheet. These tubes permit the water in the boiler to circulate through them, which prevents them from being burned by the intense heat in the fire-box. The fire-brick deflector extends backward and upward from a point on the tube sheet a short distance below the tubes. A space *A* between the top of the deflector and the crown-sheet is left open, so that the smoke and gases from the fire must pass under the deflector and around and over its back end, as indicated by the arrows in fig. 340. In this way the products of combustion are delayed in the fire-box before they enter the tubes, which gives time for the gases and air to combine and combustion to take place. The fire-brick becomes heated, and thus to some extent prevents the gases from being cooled down below an igniting temperature by contact with the cold surface of the fire-box before combustion is complete. The fire-brick, however, soon burns out, and must often be replaced, but owing to its cheapness and the ease with which it can be removed, this is not a very serious objection to its use. Air is nearly always admitted above the fire when the brick arch is used, either by tubular stay-bolts or perforations in the door, or both.

When air is admitted at the furnace door of an ordinary fire-box, it is very apt to rush directly into the tubes without mingling with the gases. It was found by some of the firemen on English railroads that by placing an inverted shovel over the top of the furnace door, the current of air which entered could thus be deflected downward, and in this way smoke could be almost entirely prevented. This led to the adoption of a hood or deflector, *A*, fig. 342, which is made of sheet iron and is placed over the fire-box door, and is arranged with a lever, *B*, so that it can be raised in order to be out of the way when coal is thrown on the fire. It is suspended from a hook, *C*, from which it can easily be detached and taken out for repairs. This is frequently necessary, as the intense heat of the fire-box burns away the sheet iron of which it is made very rapidly. It can be made of old boiler plate, so that the expense of renewal is very slight. When this plan is used, a double sliding door, shown in fig. 343, is commonly used with it. These doors are opened by the levers *f d g* and *e h*, which are connected together by the rod *r*. With these sliding doors the opening for the admission of air can easily be regulated, and the opening through

Figs. 344 and 345 represent a furnace door used on an English railroad. The door *A* is hinged so as to open inward. It is opened and closed, and its position can be adjusted by the lever *C*. *B* is a door hinged at the bottom to protect the fireman from the heat of the fire. By leaving the door partly open air is admitted and deflected downward on the fire for the reason already described.

On the New York Central & Hudson River Railroad the form of fire-box, shown in figs. 346–348, which was designed by Mr. William Buchanan, Superintendent of Machinery of that line, is used quite extensively, and avoids the inconvenience and expense of frequently replacing the fire-brick and gives very perfect combustion. This consists of what is called a water-table, *A A*—that is, two plates with water between them similar to the sides of the fire-box. This extends completely across the fire-box from the tube sheet to the back-plate, thus dividing the fire-box into two compartments, *M* and *N*. In order to afford communication from the lower one to the upper one a round hole, *D*, about 18 in. in diameter, is put in the water-table in the position shown. It will thus be seen that all the currents of gas, smoke, and air must unite in passing through this opening, and are thus brought into close contact with each other. After they enter the upper chamber and before they enter the tubes, there is room and time for combustion. For the purpose of supplying fresh air above the fire, Mr. Buchanan puts four tubes, *A A A A*—shown in an enlarged scale in figs. 349 and 350—in the front and equal number in the back end of the fire-box just above the fire. These tubes each have a cone, *C*, which has an annular opening or space, *D D*, around it. The cone is held in position by the ribs *E E*, which are attached to it. Each of these tubes has a steam nozzle, *n n*, opposite to it. Steam is conducted to these nozzles by the pipe *F F*—*F*, the supply being regulated by the cock *G*. A jet of steam can thus be discharged into each one of the tubes, the effect of which is to create what is called an *induced* current of air into the tubes, or, in other words, the steam draws a large amount of air into the tubes with it. When the steam and air strike the cone *C*, fig. 349, it deflects or spreads them as indicated by the dotted lines which diverge from the nozzles in the different figures. The effect is to distribute and mix the air with the gases in the fire-box, and thus promote combustion. The furnace doors of these fire-boxes also has a deflector, *H*, and a movable damper, *I*, which is swung on trunnions so that its position can be adjusted by the latch *L*. The air can thus enter the fire-box through the door, and is deflected downward as indicated by the arrows in fig. 346. The direction of the smoke and gases is indicated by the arrows in fig. 346, which shows how they come into contact in passing through the opening *D* in the water-table. The steam jets and the furnace door furnish the means of supplying an abundance of air to the fire, which are intimately mixed below the water-table and in passing through the opening *D*, so that very complete combustion results in the chamber *M*.

QUESTION 581. *How do the plans for burning coal which have been described operate?*

Answer. They will all burn coal more perfectly, and therefore more economically, if they are carefully and skillfully managed, than is possible in ordinary plain fire-boxes; but it is probable that as much economy in the consumption of coal would result from the improvement of the practice and knowledge of firemen as can be expected from the use of any of the appliances described, if they are used without care or knowledge of the principles of combustion.

QUESTION 582. *In what respect does anthracite coal differ from bituminous?*

Answer. It differs chiefly in the fact that it contains a much larger proportion of carbon and less of hydrogen, and in the fact that it consequently gives off very little or no coal gas. Its combustion is therefore more simple than that of bituminous coal, as there is very little else than solid carbon to burn.

QUESTION 583. *In what kind of a fire-box is anthracite usually burned?*

*Rankine.

Fig. 346.

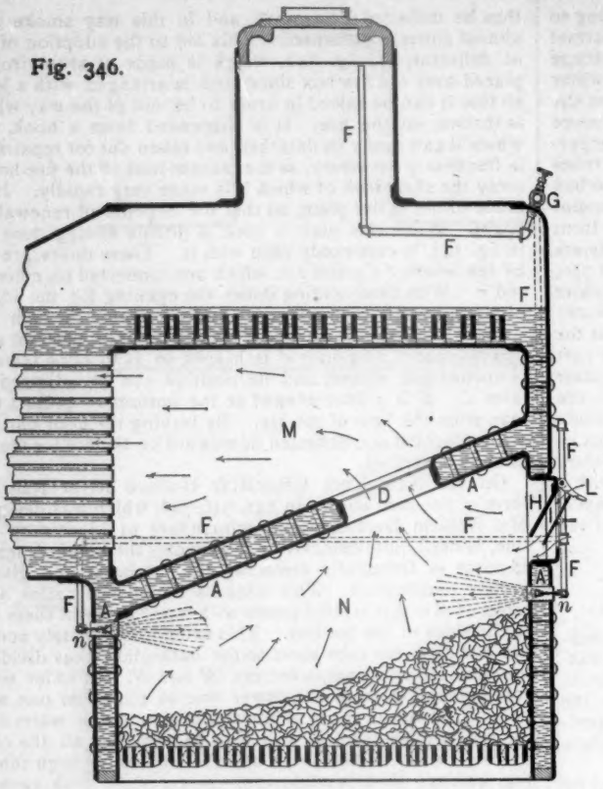
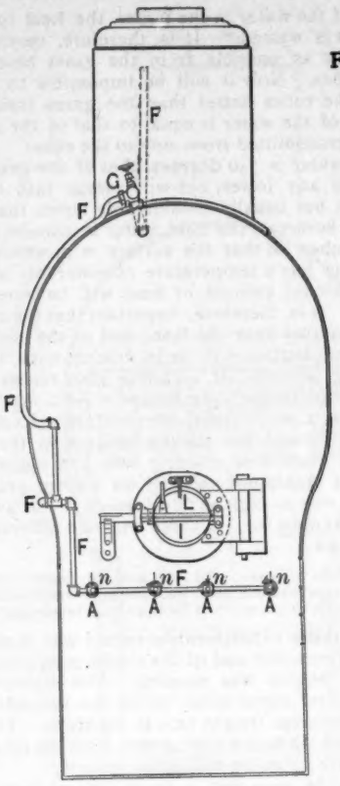


Fig. 347.



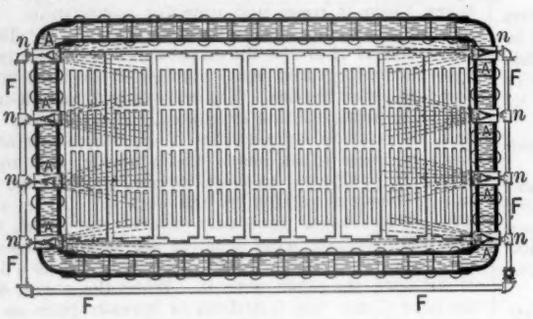


Fig. 348.

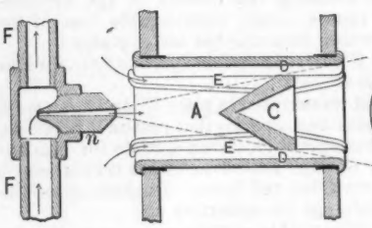
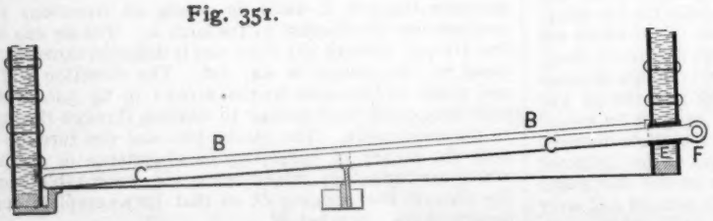


Fig. 349.

Fig. 350.

Fig. 351.



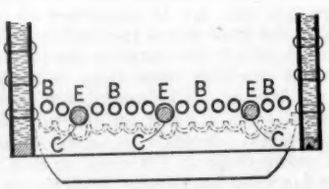


Fig. 353.

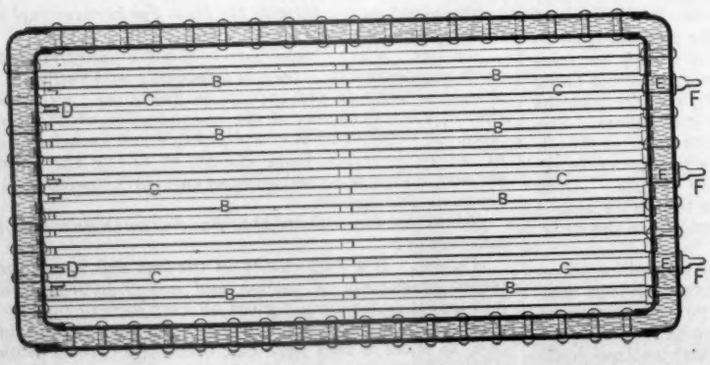


Fig. 352.

Answer. It is usually burned in a very long grate, and as the heat is very intense, the grate-bars *B B*, figs. 351–53, are usually made of iron tubes, through which a current of water circulates, so as to prevent them from melting. These tubes are screwed into the front-plate of the fire-box, and are fastened with tapered thimbles on the back ends, which are driven into holes in the back-plate so as to make a tight joint around the tube. As these tubes are fastened in the plates and are immovable, it is essential that some means be provided for drawing the fire from the fire-box. This is done by using a solid bar instead of a tube at intervals in the grate, as shown by *C C* in figs. 351–53. These solid bars rest on a support or bearing-bar, *D D*, as it is called, at the front end, and pass through tubes, *E E*, in the back end of the fire-box. These tubes are caulked in each plate so as to make them tight. The bars have eyes, *F F*, on the ends for drawing them out when the fire must be removed.

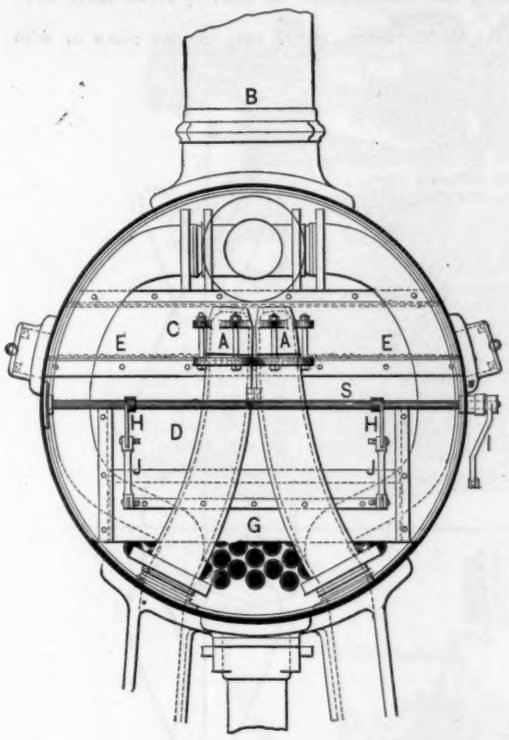


Fig. 354.

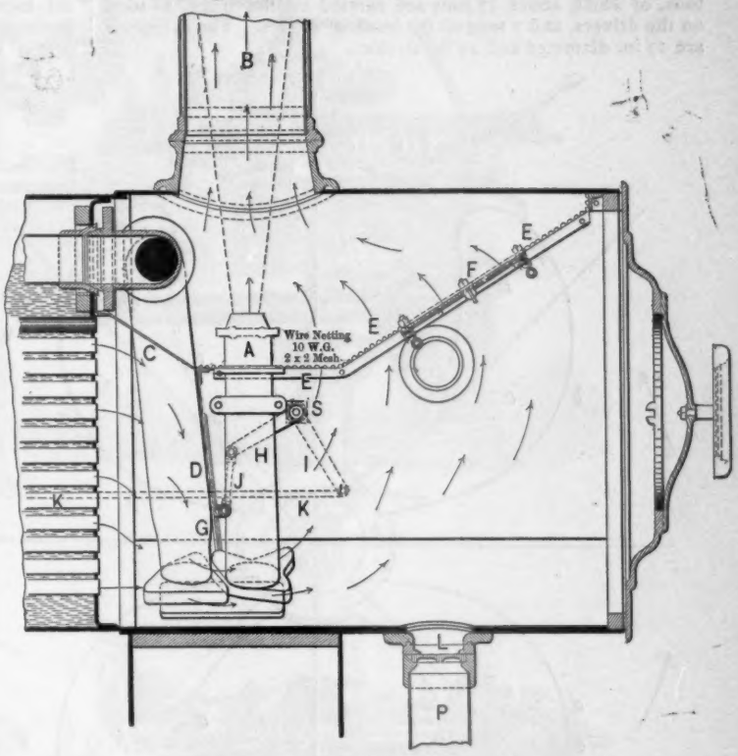


Fig. 355.

QUESTION 584. *Is it important to admit air above an anthracite coal fire to facilitate combustion?*

Answer. It is not so important as it is in bituminous coal, but if the layer of anthracite in the grates is very thick, it will be impossible to get enough air through the coal to convert all the carbon into carbonic dioxide, and the carbon and oxygen will therefore unite so as to form carbonic oxide. If air is admitted above the fire, as has already been explained, another equivalent of oxygen will unite with the carbonic oxide, and a second combustion will then take place above the fire, and the carbonic oxide will thus be converted into carbonic dioxide. If, under these circumstances, no air was admitted above the fire, the second combustion would not occur, and all the heat produced thereby would be lost.

QUESTION 585. *In what way is combustion influenced by the arrangements in the smoke-box of the locomotive?*

Answer. The draft is dependent on the proportions, location, and adjustment of the blast orifices and the other appliances used in the smoke-box. The smaller the blast orifices are the more violent will be the escape of steam and the draft of air through the fire. But the draft is also dependent on the arrangement and proportions of the wire netting, deflection chimney, and other appliances used in the smoke-box. No exact rules can be given for the arrangement of these parts, as the principles of their operation are still very imperfectly understood. The best arrangement for them must, to a very great extent, be determined by experiment.

QUESTION 586. *What is an extended smoke-box or extended front end, and what is it for?*

Answer. As its name implies, it is an extension of the smoke-box in front of the chimney, and its object is to give room for collecting sparks and cinders. Such a smoke-box is shown in plates III and IV, and also in figs. 354 and 355. In the latter figures *A A* are the exhaust orifices or nozzles; *B* is the chimney; *C* and *D* are deflectors or plates in front of the tubes. The deflector *D* has a sliding door, *G*, which is moved up and down by the shaft *S*, which has arms, *H* and *I*, the former connected to the door by rods, *J J*, and the latter by another rod, *K K*, with the cab. *E E* is wire netting which has an opening or man-hole, *F*, also covered with netting, which can be removed to give access to the exhaust nozzles.

The purpose of the movable door or deflector, *G*, is to regulate the draft, the direction of which is indicated by the arrows.

QUESTION 587. *How does an extended smoke-box help to arrest sparks and cinders?*

Answer. By means of the deflectors the sparks are thrown forward into the extension of the smoke-box where the current of air and gases is not violent. As the wire netting at the same time offers some obstruction to the movement of the sparks, they are deposited in the extension of the smoke-box, from which they can be removed by means of the pipe *P*, which is closed by a sliding door, *L*.

QUESTION 588. *How can we determine the relative value of different kinds of fuel for use in locomotives?*

Answer. This can only be determined satisfactorily by actual experiment. The chemical composition, excepting so far as it indicates the presence of deleterious substances, such as sulphur, ashes, clinkers, etc., affords but little assistance in determining the value of fuel. Nearly the same quantities of elements in different fuels may arrange themselves, before and during combustion, so as to produce very different series of compounds. It is true that the composition of coal gives us some indication of its heat-producing *capacity*, but the extent to which that capacity can be converted into actual steam in locomotive boilers depends to a very great extent upon the conditions under which the fuel is burned. It should also be remembered that the rapidity with which steam can be generated is a very important matter in locomotive practice. Whether a heavy freight train can be taken up a given grade, or a fast express make time, often depends upon the amount of steam which can be generated by the fuel in each second of time that the boiler is worked to its maximum capacity. Therefore any appliance for improving combustion, which reduces the quantity of steam which can be generated by the boiler in a given time, is quite sure to fall into disuse or be abandoned. It is of course often necessary to adapt the appliances for burning fuel to the fuel itself; and when a poor quality of the latter must be used, more boiler capacity must be given than is needed to do the same work with better fuel.

(TO BE CONTINUED.)

Manufactures.

The Strong Locomotive.

A LOCOMOTIVE of the Strong pattern,* built by the Hinkley Locomotive Company in Boston for the Strong Locomotive Company, and named the *A. G. Darwin*, has recently been running on the New York, Providence & Boston Railroad. This engine has the Strong boiler with double fire-box and is carried on 10 wheels, a four-wheeled truck forward, four driving-wheels 68 in. in diameter, and a pair of bearing-wheels under the fire-box. The two corrugated fire-boxes are 38 in. in diameter, and the boiler has 235 tubes. The engine weighs 60 tons, of which about 17 tons are carried on the truck, 36 tons on the drivers, and 7 tons on the bearing-wheels. The cylinders are 19 in. diameter and 24 in. stroke.

The engine, as might be expected from the weight and the long wheel-base, is a very steady-running one. It also worked with remarkable smoothness for a new locomotive. The quick and comparatively quiet exhaust is a striking feature to any one riding in the cab.

The *Darwin* will probably remain on the New York, Providence & Boston road for a short time, and will then be tried on several other lines.

On Monday, December 3, on the invitation of the Strong Locomotive Company, a party of gentlemen interested witnessed the performance of this locomotive on the regular Shore Line Express, this train being taken from Groton to Providence, 63 miles, by the *Darwin*. The party returned from Providence to Groton on the following day, on the regular express train, leaving at 11.10 A.M., with the same engine.

On the trip eastward the train, which consisted of eight cars, left Groton 32 minutes late, and 17 minutes of this time was made up on the trip, the run of 63 miles being made in 1 hour 40 minutes, with five stops. The road is generally in very good condition, but on the 13 miles from Stonington to Groton work is in progress on a second track, and the changes at bridges, culverts, etc., made slow running necessary. The best speed made on this trip was 13 miles in 15 minutes, from Greenwich to Providence.

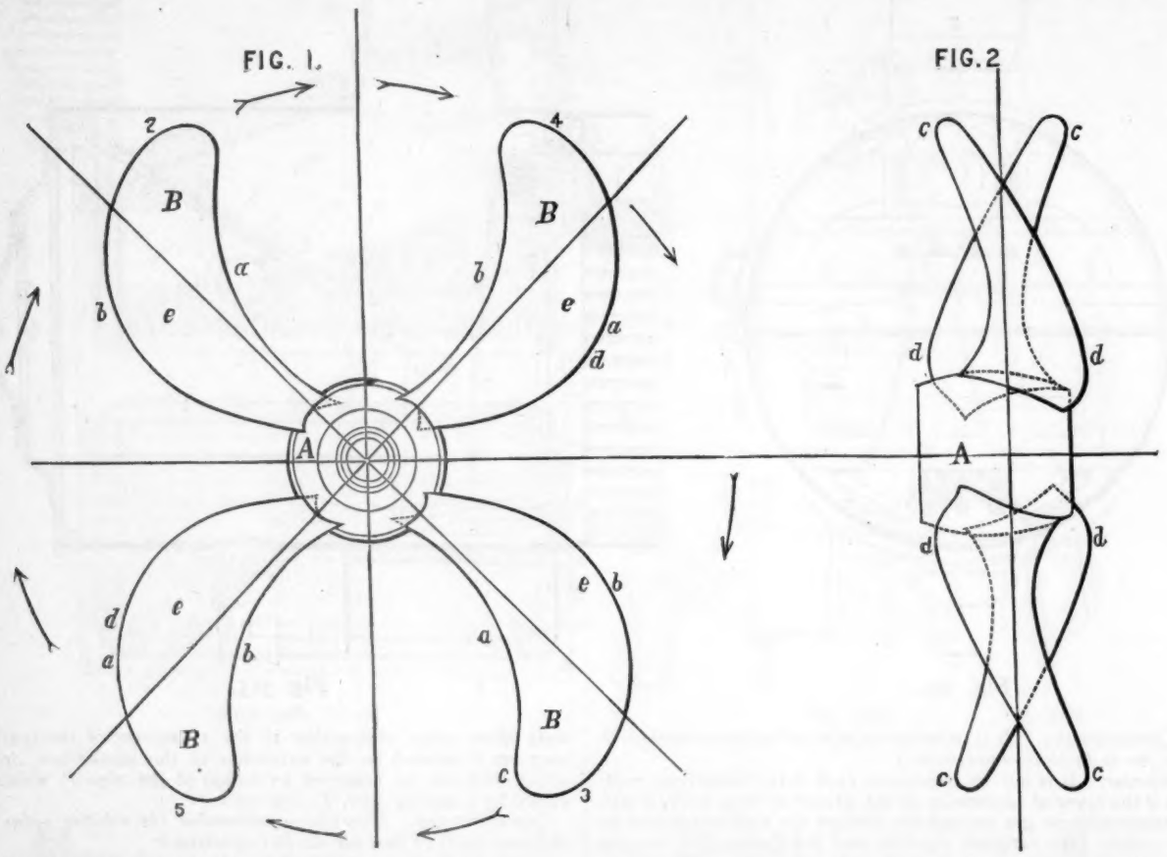
On the return trip the run from Providence to Wickford Junction, 20 miles, was made in 23½ minutes (with six cars), the engine running several successive miles in 62, 61, and 63 seconds. The supply of steam was abundant, the safety-valve blowing off nearly all the way. No attempt was made on this trip to secure any special economy or to take the quantity of fuel consumed.

* The Strong locomotive was illustrated and described in the RAILROAD AND ENGINEERING JOURNAL for March and April, 1887, pages 105 and 160.

The Vogelsang Screw Propeller.

THE accompanying illustrations represent a new form of screw propeller invented by Mr. Alexander Vogelsang, which has been in use for some time with very favorable results, its application having in several vessels increased the speed without increasing the consumption of coal, in some cases even diminishing it.

It is a four-bladed screw, either cast in one piece or with blades adjusted, but differs from ordinary propeller screws in that the center lines of two following blades form spirals running in opposite directions. The Inventor describes it as follows:



"The edges of the blades do not coincide in a plane, but cross each other in such a manner that, supposing two successive blades were folded together round the axis, their leading and trailing parts would not cover each other in a plane of projection parallel to the axis. The blades are curved in such a manner that alternately one has its leading part near the periphery and the following one near the center, but the leading part of each blade will rotate in a plane that is in advance of the preceding blade. The blades diametrically opposite each other are alike, and the blades at their point of juncture with the hub are in approximately the same plane.

"As the screw is set in rotation, each blade cuts into water in advance of the preceding blade, and in no way comes in contact with the eddies created by the latter. Each blade, in fact, will act independently of and in no way interfere with the blades preceding or following it. In consequence of the difference in the manner in which the blades work, their reciprocal action is insured, the water is permitted to freely enter the screw from the direction in which it advances, centripetal, centrifugal, or back action cannot take place; therefore, no water is whirled around between the blades, and no thrust power neutralized by

water pressing against the back of the blades. Negative slip will not be observed with this screw.

"In reversing the direction of movement, the working order of the blades is simply reversed, so that when backing the vessel the same advantages are obtained, and the useful effect of this propeller will therefore be considerably greater in either direction than that of any other known propeller."

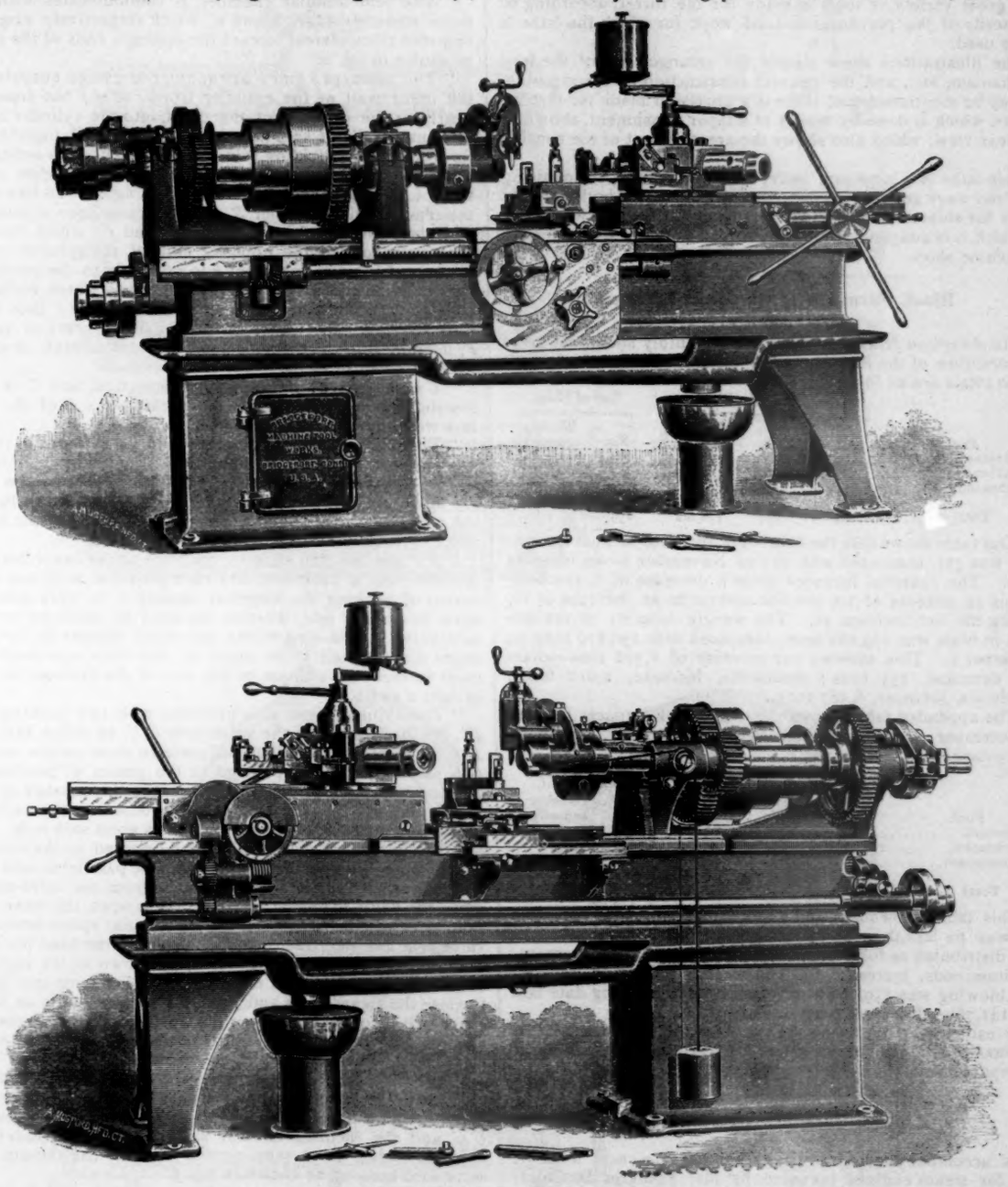
In the accompanying cut fig. 1 is a front view and fig. 2 a side view of the propeller.

Among the advantages claimed for this screw by the inventor are, that it is the only one strictly in accordance with theory; that it is the only one drawing the full supply of water for its blade area from in front, and ejecting a cylindrical column of water equal to its diameter directly astern; that from its arrangement no blade will come in contact with disturbed water; that it causes no back action within its disk and does not carry any water around with it; that it will not lose in efficiency when the speed is increased; that it will not cause shocks or vibrations to the ship; that its backing power is much greater than that of any other screw. These claims seem to be substantiated by reports of the performance of the screw in actual service.

We are informed that one of these screws has been applied to the new German fast cruiser *Greiff*, with the result of increasing the speed from 19.75 knots to 22.8 knots per hour, the latter speed being the average of two days' continuous running.

A Combination Turret Lathe.

THE accompanying illustrations show a combination turret lathe made by the Bridgeport Machine Tool Works, at Bridgeport, Conn., which is intended for making screws or studs of all kinds up to 2 in. diameter, and also for general work. It is a tool remarkable for the variety of work which it is able to perform and for its careful design and construction.



COMBINATION TURRET LATHE.

The head has a three-section cone for a 4-in. belt, the largest section being 14 in. in diameter. It is provided with a patent friction clutch for instantly changing from belt speed to back gears without stopping. The gearing is proportioned to secure the proper relation of speed between the cutters and dies. The hole through the spindle is 2¼ in. in diameter. The chasing-bar is provided with proper leaders for cross pitches.

The machine is provided with a regular lathe carriage, which has reversible cross and lateral feeds and taper attachment; also three tool-posts to be used for studs and screws, or for general turning.

The turret is hexagon in form, 12 in. in diameter, with six 2¼-in. holes, and has 14-in. automatic feed and stop motion, and is self-revolving. A substantial chuck for square, round, or hexagon iron is provided.

The counter-shaft has three pulleys 16 in. in diameter for a 4 in. belt, this giving two speeds forward (75 and 150) and one speed backward (150).

A great variety of tools is made for the turret, according to the needs of the purchaser and the work for which the lathe is to be used.

The illustrations show clearly the arrangement of the feed mechanism, etc., and the general construction of the machine. It may be mentioned that there is a provision made for turning tapers, which is done by means of a taper attachment, shown in the rear view, which also shows the arrangement of the chasing bar.

This lathe is a large and heavy machine, having 20-in. swing over the ways and 11¼ in. over the carriage. Its entire weight ready for shipment is 4,500 lbs. Owing to the variety of work to which it is adapted, it must be an exceedingly useful tool in a machine shop.

Blast Furnaces of the United States.

THE *American Manufacturer's* usual monthly statement gives the condition of the blast furnaces on December 1, and says: "The totals are as follows:

	In Blast.		Out of Blast.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	13,270	95	11,329
Anthracite	107	31,052	89	23,082
Bituminous	151	94,960	75	34,736
Total	331	139,282	259	69,147

"Our table shows that the number of furnaces in blast December 1 was 331, compared with 313 on November 1—an increase of 18. The charcoal furnaces show a decrease of 2, the bituminous an increase of 10, and the anthracite an increase of 10, making the net increase 18. The weekly capacity of the furnaces in blast was 139,282 tons, compared with 130,270 tons on November 1. This shows a net increase of 8,562 tons—charcoal, decrease, 735 tons; anthracite, increase, 2,610 tons; bituminous, increase, 6,587 tons.

"The appended table shows the number of furnaces in blast on December 1, 1888, and on December 1, 1887, with their weekly capacity:

	Dec. 1, 1888.		Dec. 1, 1887.	
Fuel.	No.	Weekly capacity.	No.	Weekly capacity.
Charcoal	73	13,270	73	13,104
Anthracite	107	31,052	120	35,361
Bituminous	151	94,960	148	93,295
Total	331	139,282	341	141,760

"This table shows that the number of furnaces in blast this year was 10 less than at the same date in 1887, the changes being distributed as follows: Charcoal, 0; anthracite, decrease, 13; bituminous, increase, 3. The weekly capacity of the furnaces blowing was 139,282 tons; at the corresponding date last year, 141,760—decrease, 2,478 tons."

The estimated production of pig iron for the year 1888 is 5,956,000 tons, a decrease of about 461,000 tons, or 7¼ per cent., as compared with 1887.

Child's Patent Piston Valve.

THE accompanying illustrations represent a new form of valve for steam engines invented by Mr. Franklin D. Child, Manager of the Hinkley Locomotive Works, and recently patented by him. In this arrangement, as will be seen, a separate steam-chest is dispensed with; the ports run entirely around the cylinder and are opened and closed by annular pistons working inside the cylinder itself. The valve is thus described:

"Fig. 1 is an end elevation of the larger part of a steam-engine cylinder having my invention applied thereto. Fig. 2 is a longitudinal section on line *x x* on figs. 1 and 5, but showing the piston and piston-rod in plan. Fig. 3 is a half-section on line *y y* on fig. 1, showing the piston, piston-rod, and valve-rods in elevation, and also showing a different packing for the valves. Fig. 4 is a transverse section on line *z z* on fig. 2. Fig. 5 represents in its upper half a transverse half-section on line *v v* on fig. 2, and in its lower half a similar half-section on line *w w* on fig. 2. Fig. 6 is a longitudinal half-section illustrating a form of my invention to be used in applying the invention to engines already in use, and fig. 7 is an end view of same.

"In the drawings, *A* is the steam-cylinder provided at one side and at or near the center of its length with the steam-inlet pipe *A'*, and at the opposite side with an exhaust-pipe, A^2, the former communicating with the semi-annular chamber *B*, which is separated from the semi-annular chamber *B'*, with which the exhaust-pipe communicates, by the partitions *a* and *a'*, which are shown in section in fig. 4, and one of which is indicated by dotted lines in fig. 2 and shown in longitudinal section in fig. 3.

"The semi-annular chamber *B* communicates with the annular steam-passages *b* and *b'*, which respectively extend from opposite sides thereof toward the opposite ends of the cylinder, as shown in fig. 2.

"The passages *b* and *b'* are annular or extend entirely around the inner wall of the cylinder from *c* to *d*; but from *d* to or nearly to the opening of the ports into the cylinder the inner and outer walls of said passages are connected together by the tie-ribs *e e*, thus dividing said passages each into a series of passages or ports, *e'*, opening into the cylinder upon all sides thereof, as shown in the upper half of fig. 5. In like manner, the semi-annular chamber *B'* communicates upon opposite sides with the annular exhaust-passages *f* and *f'*, which extend, respectively, toward the opposite ends of the cylinder from *g* to *h* in annular form, and from *h* to or nearly to the points where they open into the cylinder the inner and outer walls of said passages are connected together by the tie-ribs *i*, thus dividing said passages each into a series of exhaust-ports or passages, *i'*, opening into the cylinder upon all sides thereof, as shown in the lower half of fig. 5.

"*C* is the piston, of ordinary construction, and *C'* is the piston-rod, having a bearing in the packing-box *D* of the head *E* in a well-known manner.

"The heads *E* and *E'* are secured to the cylinder in the usual manner, and are provided upon their inner sides with large inwardly-projecting hollow hubs, which in the case of new engines are made in the form of frustums of cones, as shown in fig. 2; but when applied to remodelling old engines the said hubs are made cylindrical, as shown in fig. 6.

"*F F* are two ring slide-valves fitted to the inner bore of the cylinder, one at each end, and each provided with any suitable means of packing the same or causing it to work steam-tight upon its circular seat, whether the same be inside or outside of said valve. Said ring-valves are made thinner at their outer edges than at their inner edges, so that their non-working circular surfaces are oblique to the axis of the cylinder, as shown in figs. 2 and 6.

"The cylinder-head *E* is provided with two packing-boxes, E^2, for the passage of the valve-rods *G G*, by which said valves *F F* are connected together and made to move as one, said rods *G G* passing through openings in the piston *C*, provided with packing-boxes *j j* (see fig. 4) to prevent the passage of steam from one side of said piston to the other as the rods move through said piston or the piston moves upon said rods.

"The portion of the cylinder-head opposed to the oblique or frusto-conical surface of the valve is made parallel to said frusto-conical surface, and at such a distance from the valve-seat that when the valve is moved into position to open the steam-ports, said valve will substantially fill the annular space between the valve-seat and said frusto-conical surface of the head for the full longitudinal length of said valve, as shown at the right-hand ends of figs. 2 and 6, and when the valve is moved into position to close the steam-ports and open the exhaust-ports an annular space will be opened between the frusto-conical surfaces of the valve and of the head to permit the free passage of the exhaust steam to the exhaust-ports of the cylinder.

"The inclined circular sides of the valves *F F* are each provided with two ears, *k k*, upon opposite sides of the piston-rod, in which ears are formed openings to receive the valve-rods *G G*, and the inclined circular surfaces of the cylinder-heads opposed thereto have semi-circular notches cut therein to receive said ears, all as shown in fig. 5.

"For the purpose of remodelling old engines and applying my improved valves thereto, I make the steam-inlet and exhaust-nozzles and ports in the cylinder-heads instead of in the cylinder, and form the valve-seats upon the inwardly-projecting central portions of said heads, as shown in figs. 6 and 7.

"In some cases I propose to cut the tie-ribs *e* and *i* short of the inner periphery of the cylinder, as shown in fig. 3, thereby making a continuous port extending entirely around the cylinder, instead of making a series of ports separated only by thin partitions or ribs, as hereinbefore described."

The advantages claimed are the long port extending around the cylinder, thus giving full opening with a short stroke, and the reduction to a minimum of the space to be filled with steam at each stroke.

Marine Engineering.

THE Cleveland *Plain Dealer* publishes a list of new vessels under contract for service on the Lakes to be built during the present season. The total is 59 ships, with a carrying capacity of 100,950 tons, and to cost about $7,124,000. Last season there were built 60 vessels, with a capacity of 108,525 tons, and costing $8,325,000.

IN the yard of Neafie & Levy, Philadelphia, work has been begun on a new steam-tug 102 ft. long, 20 ft. beam and 10 ft. depth of hold. She will have a triple-expansion engine with cylinders 14 in., 21 in. and 36 in. diameter and 28 in. stroke.

A NEW steam-tug for Baltimore Harbor, just completed at the yard of John H. Dialogue & Company, Camden, N. J., is 106 ft. long, 21 ft. beam and 11 ft. hold, of iron, the plating being $\frac{7}{16}$ and $\frac{1}{2}$ in. The engines are triple-expansion, with cylinders 13 in., 21 in. and 32 in. diameter and 24 in. stroke. They will have about 150 lbs. working pressure of steam.

Manufacturing Notes.

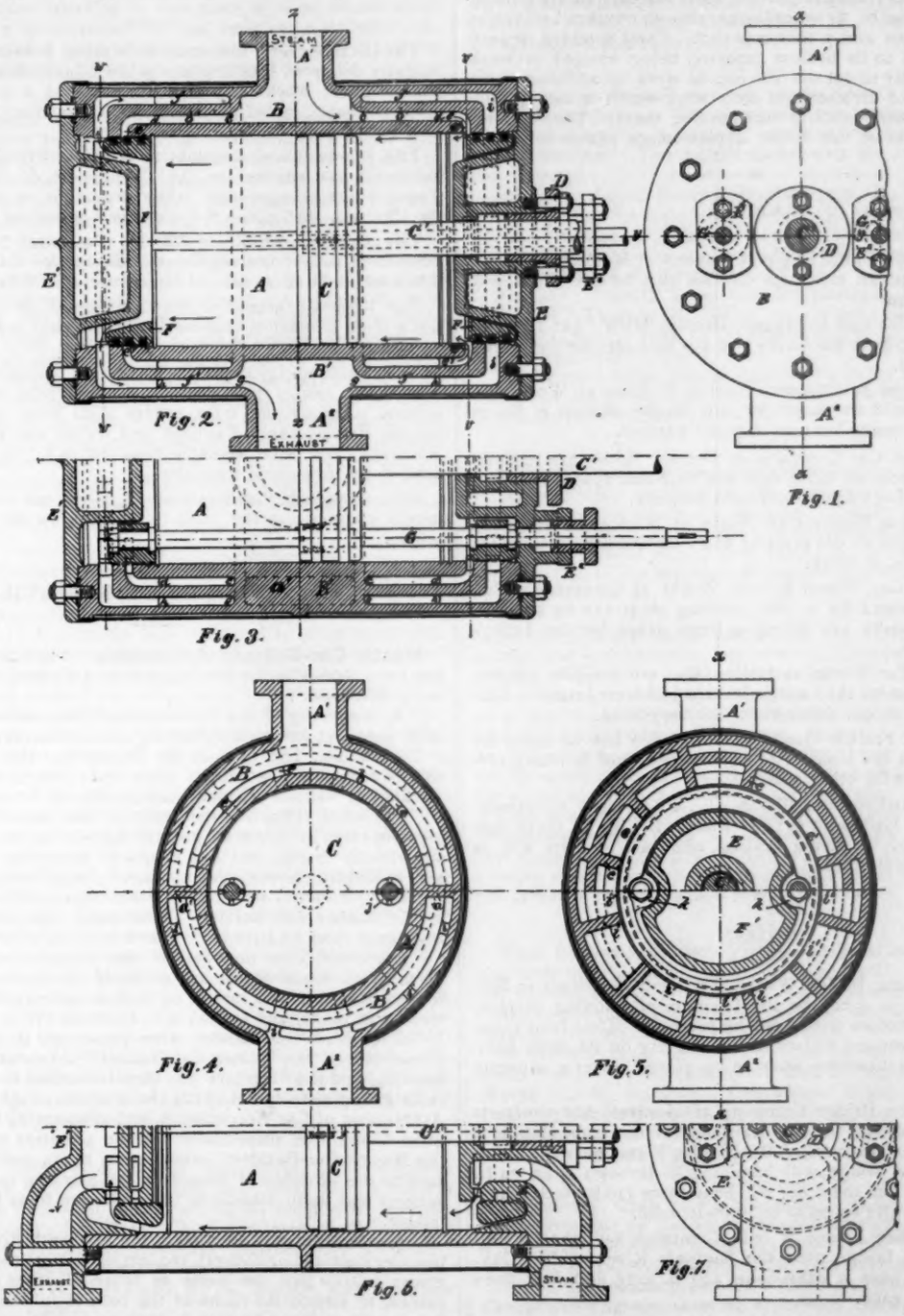
THE contract for the tools for the new machine shops of the Louisville & Nashville Railroad at Decatur, Ala., has been taken by Manning, Maxwell & Moore, of New York.

THE Missouri Iron Roofing & Corrugating Company in St. Louis is very busy, having made large sales of its iron roofing and siding in the South and Southwest.

THE Cincinnati Corrugating Company has recently issued a circular giving a number of striking instances of long life of corrugated iron roofs under trying circumstances.

THE Bethlehem Iron Company, Bethlehem, Pa., is nearly ready to start up its new steel plant, which has been built chiefly for the purpose of making heavy forgings for guns and armor-plates. The first work done will be on the forgings for the 8-in., 10-in., and 12 in. guns for the Navy.

THE Sioux City Foundry & Machine Works, Sioux City, Ia., recently sold two of their 75 H.-P. Corliss engines for the new



Pioneer-Press building at St. Paul, Minn.; also two others of the same size to run electric light plants at David City, Neb., and Storm Lake, Ia. These works also recently sold the first of a new line of engines, a 10 × 16 in. cylinder Giddings single-valve automatic engine for the water-works at Chillicothe, Mo. Arrangements are being made to manufacture several sizes of this engine. In addition to this the Works have recently sold several large boiler plants, together with a number of combined outfits of the Erie Engine Works, manufactured by Cleveland & Hardwick, of Erie, Pa., for which they are Western agents. They are still very busy improving their works, and are putting in at present a 90-in. fly-wheel lathe, also an overhead traveling crane, 30 ft. span and 7 tons capacity. Their foundry department is driven to its utmost capacity, being obliged to work evenings in order to get out the engine work in addition to the large amounts of architectural iron work which is required by the rapidly growing country surrounding them. They also report several sales of the Miller duplex steam pumps for boiler feeding.

Cars.

THE Muskegon Car & Engine Company at Muskegon, Mich., recently received an order for 500 box cars for the Chicago & Atlantic Railroad.

THE Peninsular Car Company, Detroit, Mich., has received an order for 350 box, 300 stock, and 450 coal cars for the Union Pacific Railroad.

THE car shops of Osgood Bradley & Sons at Worcester, Mass., are to build 20 passenger cars for the Boston & Maine Railroad, to be ready for next summer's travel.

THE Michigan Car Company in Detroit, Mich., has recently received contracts to build 650 box cars and 250 refrigerator cars for the Union Pacific Railroad Company.

THE Haskell & Barker Car Works at Michigan City, Ind., are to be enlarged by the erection of a new blacksmith shop 164 by 130 ft. in size, of brick.

THE Lehigh Car, Wheel & Axle Works at Catasauqua, Pa., have been enlarged by a new erecting shop 132 by 50 ft. in size. These works are filling a large order for the Lehigh Valley Railroad.

THE Milton Car Works at Milton, Pa., are building 500 box and 500 coal cars for the Central Railroad of New Jersey. Like most of the car shops, these works are very busy.

THE Wells & French Company in Chicago has an order for 150 coal cars for the Union Pacific Railroad, and is filling several large orders for other roads.

THE Pullman shops at Pullman, Ill., are to build 30 passenger cars for the Baltimore & Ohio Railroad. All of these cars will be equipped for steam heating, and part of them will be provided with vestibules.

Bridges.

THE Edge Moor Bridge Works have been organized at Wilmington, Del., to carry on the business of building bridges, roofs, etc., heretofore conducted by the Edge Moor Iron Company. That company will continue to carry on its other business, the bridge business only being placed under a separate management.

THE Dominion Bridge Company at Montreal has contracts from the Drummond County Railroad for the construction of two bridges over branches of the Nicolet River, near St. Leonard, P. Q. One bridge will have 160 ft. through span, 34 ft. above the river, and the other will have three 110 ft. deck spans, and 280 ft. of girder spans of 30 to 60 ft. each.

THE Milwaukee Bridge & Iron Company has taken a contract to build a bridge over the Saginaw River at Bay City, Mich. It will have a draw-span 240 ft. long and four fixed spans of 150 ft. each.

Electric Notes.

THE East End Electric Light Company has taken a contract to light the entire city of Pittsburgh with arc and incandescent lights for the year 1889 at a contract price of $110,592 per year. The Waterhouse system of arc lights, now owned by the Westinghouse Electric Company, will be used for the arc lights, while the Westinghouse system will be used for the incandescents. It is said that this is the lowest contract for electric lighting ever taken. The candle power of gas and gasoline used by the city now is 83,200; of electric light there will be 907,175, or ten times as much for less money. The cost per arc light per night will be about 29 cents. In Detroit it costs 62½ cents; Buffalo, 50 cents; New York, 50 to 70 cents; Baltimore, 40 cents; Philadelphia, 50 cents.

Locomotives.

THE Schenectady Locomotive Works, Schenectady, N. Y., recently delivered four engines to the Chesapeake & Ohio Railroad. These works are very busy, having a number of contracts on hand, including one for 25 locomotives for the Union Pacific.

THE Rhode Island Locomotive Works in Providence recently delivered five engines to the Chesapeake & Ohio Railroad. These works have recently taken orders for 15 locomotives for the Chicago, Burlington & Quincy and 25 for the Union Pacific.

THE Cooke Locomotive Works, Paterson, N. J., recently completed 10 locomotives for the Chesapeake & Ohio Railroad. They are at work on several large orders for different roads.

THE Rogers Locomotive Works, Paterson, N. J., have turned out a large number of engines during the past year, and are still very busy.

THE Baldwin Locomotive Works in Philadelphia in 1888 turned out nearly 700 locomotives, including several foreign orders. Among the large orders filled were 50 locomotives for the Pennsylvania Railroad and 60 for the Philadelphia & Reading. An order recently received is for 30 engines for a road in the Argentine Republic.

THE Canadian Pacific shops at Montreal are building 10 mogul engines for the road in addition to 20 recently completed.

PROCEEDINGS OF SOCIETIES.

Master Car-Builders' Association.—The following circular has been issued by the Secretary from his office, No. 45 Broadway, New York:

"At a meeting of the International Association of Accountants, held last June, the following resolutions were adopted:

"'*Whereas*, The rules of the Master Car-Builders' Association in regard to the proper marking of freight cars are being violated by various railroads and private car lines; therefore,

"'*Resolved*, That it is the sense of this Association that immediate steps be taken to prevent the placing of elaborate and superfluous marks and the names of more than one railroad, also misleading advertisements, upon freight cars, and that our Secretary is hereby directed to communicate with the Secretary of the Master Car-Builders' Association and respectfully ask that these rules be strictly complied with; and further,

"'*Resolved*, That members of this Association who are connected with roads which are guilty of the above violation, be requested to take this matter up with the proper officers of their respective roads, and endeavor to have the evil remedied.'

"The above resolutions were presented to the Executive Committee of the Master Car-Builders' Association at its last meeting, and the Secretary was then instructed to prepare a circular giving a statement of the above action of the International Association of Car Accountants, and announcing that the Executive Committee respectfully call the attention of members of the Master Car-Builders' Association to its action with reference to the adoption of standards for marking cars, and would suggest that these standards be conformed to as far as is practicable.

"A resolution was adopted at the Sixteenth Annual Convention (*see page* 158 *of Report*), requesting all railroad companies whose initials are the same as those of other railroad companies, to stencil the name of the road in full on some part of the car where it can readily be seen by freight agents.

"At the Eighteenth Annual Convention, held in Saratoga (*see page* 96 *of the Report of that meeting*), the following resolutions were adopted, which describe a proposed system of lettering and numbering 'Fast Freight Line' cars:

"1. The half of sides of car on which the doors do not slide, to show the name of the Fast Freight Line (spelled out in full) and the car number (in the Fast Freight Line series) immediately below it. In the same panel and within 2 ft. of the sill shall appear (in letters not over 4 in. high) the name of the railroad company owning or contributing the car, and between

the same and the sill shall appear the light weight of the car, with such other information as it is found advisable to give in connection with same.

"2. The doors should have no marks whatever.

"3. The ends to show the initials of the Fast Freight Line with the car number (in the Fast Freight Line series) and the light weight just below them; no other marks will appear on ends of car.

"4. The half sides of cars on which the doors do slide, to be reserved for advertising symbols or trade-marks where used. The use of profuse lettering in this panel is to be discouraged, however, and it is recommended that only the simplest trade-marks or advertising signs should be used; the capacity of the car to appear near the sill in this same panel."

The Engineers' Club.—In New York, December 4, a number of gentlemen interested in the formation of a social club whose object is to draw more closely together those engaged in the kindred pursuits, met at the rooms of the American Society of Civil Engineers, in New York. The organization was perfected, the incorporators being: James A. Burden, H. R. Towne, J. C. Bayles, A. C. Rand, David Williams, B. S. Church, Edward Cooper, Thomas Egleston, W. G. Hamilton, J. F. Holloway, W. A. Perry, J. C. Pratt, R. W. Raymond, and F. S. Witherbee. Its present officers are: James A. Burden, President; H. R. Towne and James C. Bayles, Vice-Presidents; A. C. Rand, Treasurer; David Williams, Secretary.

The responses received at an earlier stage of the movement encourage the belief that the new club will start with a large and representative membership. A circular has been issued to members of the three great engineering societies inviting their co-operation and placing before them the details. We may state that engineers residing within 150 miles of New York are eligible to membership, the initiation fee being $50 and the annual dues $35. For non-resident members the admission fee is $50 and the annual dues $20.

American Society of Mechanical Engineers.—Secretary F. R. Hutton has issued a circular announcing an invitation received from the Institution of Mechanical Engineers to a meeting to be held in London in May next. The programme proposed includes joint meetings with the English Society, several excursions, and a visit to Paris. The Secretary says:

"These communications have been before the Council of your Society, and the matter has been referred to the undersigned as a Committee to investigate and report. This circular has therefore been prepared, and is sent to all the members, with the request that each will reply stating his intentions. There must be a sufficient number of representative engineers who intend to go to make it expedient to accept the invitation. The Committee have the following facts: Minimum absence, five weeks. From last week in May to first week in July. Round trip passage by steamer, $110, going altogether in a body and returning individually at any time during the year, as may be convenient. Cost per day per person on shore from $4 upward, according to personal ideas.

"The trip will begin soon after the adjournment of the Erie City Convention of the Mechanical Engineers.

"The Inman Line will reserve for our party either the steamer *City of Richmond* or the *City of Chester*, giving us the entire first cabin for our exclusive use, provided we will guarantee 150 persons, including the ladies, at the above rates. By having our own steamer, the sailing day may be fixed to suit our convenience, to say nothing of the social advantage of being by ourselves and in control of the ship."

American Society of Naval Engineers.—The engineer officers of the Navy have formed themselves into a society known as the American Society of Naval Engineers, with the following officers: President, Chief Engineer N. P. Towne; Secretary and Treasurer, Assistant Engineer R. S. Griffin; Members of Council, the above-named officers, Passed Assistant Engineers G. W. Baird and A. M. Mattice, and Assistant Engineer Emil Theiss.

The object of the Society is to promote a knowledge of naval engineering by the reading, discussion, and publication of papers on professional subjects; by the bringing together of the results of experience acquired by engineers in all parts of the world, which, though valueless when unconnected, tend much to the advancement of engineering when published in the *Journal* of the Society, and by the publication of the results of such experimental and other inquiries as may be deemed essential to the advancement of the science. Engineer officers and persons in civil life who were formerly officers of the corps are eligible as members; persons in civil life whose knowledge of engineering is such that they can co-operate with naval engineers in the promotion of professional knowledge are eligible as associates.

American Society of Civil Engineers.—At the regular meeting, November 21, the Secretary read a paper by C. D. Purdon on the Construction of the Bridge over the Arkansas River at Van Buren.

Remarks were made by Charles Sooysmith, Charles Macdonald, Francis Collingwood, and T. C. Clarke about the sinking and adjustment of the caissons of the bridges at Van Buren, Havre de Grace, Md., Hawkesbury, in New South Wales, Poughkeepsie and Brooklyn, N. Y.

THE regular meeting was held at the Society's house in New York, December 5. The Secretary announced the death of Samuel B. Cushing, a member, and also of Henry W. B. Phinney, a member. The tellers announced the following candidates elected:

Members: Alfred Craven, Dobbs Ferry, N. Y.; George W. Freeman, Fort Stevens, Ore.; William E. McClintock, Chelsea, Mass.; Norman J. Nichols, Honda, Colombia; Henry W. Potter, City of Mexico; Edward H. Stone, Simla, India; Samuel C. Weiskopf, Pittsburgh, Pa.

Associate: John C. Trautwine, Philadelphia, Pa.

Juniors: Thomas W. Allen, New York; Mark Fargusson, Brooklyn, N. Y.; John M. Farley, Albany, N. Y.; Charles F. Wood, New Haven, Conn.

Mr. Edward Bates Dorsey then read a paper on English and American Railroads, comparing them with reference to their operating expenses and rates.

A circular has been issued by the Secretary calling attention to the invitation received by the Society to visit England in May next. It is necessary, in order to make proper arrangements for this trip, to find out how many members will go, and the circular is sent out for that purpose. It is very similar in terms to that of the Mechanical Engineers, published elsewhere.

United States Naval Institute.—At a meeting of the Institute held in Annapolis, December 14, Commander P. F. Harrington delivered a lecture on the Ram as a Naval Weapon. He referred at considerable length to experiments made abroad as to the causes of lack of "handiness" in certain ships, and said that further experiments were necessary. In war-vessels, as now constructed, quickness in turning was almost as essential as speed and other qualities. It has often been said that the speed of a fleet is that of the slowest vessel in it, and to this it may be added that the manœuvring of a fleet in action would practically depend upon the curve which can be described by the vessel with the poorest turning qualities. Quickness in turning and manœuvring is an essential quality in considering the power of the vessel as a ram.

New England Water-Works Association.—The regular quarterly meeting was held at Young's Hotel, Boston, December 12, with a large attendance. The first session was devoted to the consideration of general business, applications for membership, etc., and was followed by lunch.

At the afternoon session, after lunch, the following papers were presented: Construction and Management of Water Works, C. W. Kingsley, Cambridge, Mass.; Safe Ratio of Pumping Capacity to Maximum Consumption, W. B. Sherman, Providence, R. I.; Water in Some of Its Higher Relations, Rev. D. N. Beach, Cambridge, Mass.

Engineers' Club of Philadelphia.—At the regular meeting held November 17, the Secretary presented for Mr. A. A. Storrs a description of Poore's Endless Rope Hoist for Shafts, which is said to be especially adapted for very deep shafts.

Mr. J. E. Codman presented a paper on Indicator Cards from Compound Engines, showing expansion through high and low-pressure cylinders, profusely illustrated by large copies of diagrams, etc.

The paper was discussed by Messrs. H. W. Spangler and A. Marichal.

Mr. A. Marichal discussed the Plans of the Quaker Bridge Dam as proposed by the Board of Experts appointed by the New York Aqueduct Commission, and made comparisons between them and the plans presented by himself to the Commission at the beginning of this year.

There was some discussions by Mr. H. B. Seaman.

Mr. John T. Boyd presented for discussion a sketch of a de-

sign for a Stove for Heating and Steam Purposes, which he had seen in operation and which generated an apparently immense amount of effective heat in proportion to the coal consumed.

After some discussion, the Club adjourned.

AT the regular meeting of December 1 the Tellers reported that the following were elected: *Active Members:* Sanford K. Campbell, Clifford Stanley Sims, Jr., John H. Webster, Jr., Walter Brinton, Albert S. Coffin, Charles Silliman, and Frederick B. Miles; *Associate Member:* Professor C. Herschel Koyl.

The Committee on Design and Inspection of Highway Bridges, etc., stated that they had no further report to make at present.

The Committee to Recommend a Practical Method of Testing Cements reported progress.

Officers, to serve during 1889, were nominated.

The Secretary presented, for Mr. Heber S. Thompson, a paper on Earth Embankments for Reservoirs.

Mr. Howard Murphy discussed this subject, presenting an informal account of a recent accident to a part of one of the basins of the reservoir at Roanoke, Va., when, after the explosion of a magazine containing three tons of dynamite and 400 kegs of powder, within 2,500 feet of the reservoir, a portion of the embankment of the south basin dropped into a limestone cavern or crevice, which was already known to exist under that portion.

Mr. L. F. Rondinella exhibited and described the Scale of Proportional Inches which he has prepared.

Mr. J. E. Codman presented a further discussion of his recent paper on Indicator Cards from Compound Engines, showing expansion through high and low-pressure cylinders.

Engineers' Club of St. Louis.—At the regular meeting in St. Louis, November 21, the following members were elected: Grant Beebee, Edmund Hall, William S. Love, William J. McNulty, R. L. Van Sant, and Arthur T. Woods.

Mr. Robert Moore read a paper on Smoke Prevention, in which he showed that no saving need be expected, but that experiments showed a loss of 40 per cent. in boiler capacity when making no smoke. Most smokeless fuels cost too much, as compared with ordinary coal, to come into general use. In the author's opinion, the fuel promising the best results at reasonable cost was petroleum, already coming into extensive use. The increased cost of insurance and the odor, however, were disadvantages. Good results might be secured from that class of smoke preventers which introduced air above the grates by means of steam jets, providing no injury resulted to the boilers.

This paper was discussed at much length by Messrs. Bryan, Meier, Wheeler, Bartlett, Holeman, Smith, Gale, and others.

It was decided to have the discussions at the Club meetings fully reported hereafter.

Arkansas Society of Engineers, Architects, and Surveyors.—The second annual meeting was held at Little Rock, November 22, 23, and 24. Several new members were chosen. The following officers were elected: President, Theodore Hartman; Vice-Presidents, A. B. Matson, Thomas Harding, and B. S. Wise; Corresponding Secretary, F. J. H. Rickon; Recording Secretary, F. W. Gibb; Treasurer, J. H. Haney.

The following papers were presented: Fort Smith Sewerage System, J. P. Bates; Municipal Improvement of Little Rock, G. P. C. Rumbough; Water-Works of Texarkana, A. B. Matson; Concrete in Construction, J. T. Hogane; Water-Works of Rogers, Ark., J. M. Whitham; Electric Lighting of Towns, W. E. Anderson; Arkansas Timber, E. C. Buchanan; What is Generally Expected of a Surveyor, W. E. Keefer; Descriptions in Deeds, B. S. Wise and William Mitchell; Construction of Hydraulic Rams, George C. Schoff; Uses of the Plane Table, D. C. B. Aiken; Highway Bridges, Lee Treadwell.

The meeting was well attended and successful.

Engineers' Club of Kansas City.—At the regular meeting, November 19, Dr. Wellington Adams gave an address on the Present Status of the Electric Railroad Problem, being in part a discussion of the paper read at the previous meeting. This was discussed by Messrs. Knight, Wynne, and Lawless, the latter giving a review of a recent trip of inspection of the electric street railroads of Allegheny City, Binghamton, Richmond, and Harrisburg.

THE annual meeting was held in the Club-room in Kansas City, December 5. The report of the Executive Committee was presented by the President, and that of the Committee on Bridge Reform by W. H. Breithaupt. The Treasurer also presented his report. The report of the Secretary, Kenneth Allen, showed that during the past year there were held one annual, ten regular, and three adjourned meetings; it also gave a list of the papers presented by members, and recited the various actions taken by the Club. There are now 62 regular and 6 associate members. Many additions to the library were made during the year.

Nominations for officers for the ensuing year were made. It was voted to expend about $40 in subscriptions to leading engineering journals. Mr. Burton presented the Club with two photographs of a Corliss engine constructed by him.

Boston Society of Civil Engineers.—At the regular meeting, November 21, the Secretary read a paper by J. D. Mason describing the Flushing Tunnel recently constructed in Milwaukee.

Chief Engineer A. Fteley gave a description of the New Croton Aqueduct of New York, illustrated by lantern views.

Engineers' Club of Cincinnati.—The annual meeting was held December 5; seven applicants were elected members, increasing the membership to 75.

Colonel W. E. Merrill, the retiring President, read an address, reviewing in a brief but comprehensive manner the progress of engineering during the past year.

The following officers were then elected for the ensuing year: President, G. Bouscaren; Vice-President, G. B. Nicholson; Secretary and Treasurer, J. F. Wilson; Directors, Colonel W. E. Merrill, Latham Anderson, and R. L. Read.

Franklin Institute.—The subjects for the lectures to be delivered before this Institute during the month of January are as follows:

January 7: Relations Between Chemistry and Electricity; Professor Ira Remsen.

January 14: Interchangeable Work; W. M. Barr.

January 21: Manufacture of Bessemer Steel; Robert W. Hunt.

January 28: Debt of Medical and Sanitary Science to Synthetic Chemistry; Professor Samuel P. Sadtler.

Western Society of Engineers.—At the regular meeting in Chicago, November 14, Lewis P. Pennypacker was elected a member. The Secretary read a letter from Professor A. D. Conover, of the University of Wisconsin, stating that a system of tests of all cements used in this country had been undertaken, and requesting information. The Secretary was directed to reply.

The Committee on Bridges reported progress, and the question of legislation on this subject was discussed. The Secretary presented the question of requiring all plans for waterworks and sewerage to be approved by the State Board of Health, but no action was taken.

An interesting paper, on the Necessity of a Definite and Determinate System of Weights and Measures, by Mr. Charles C. Breed, was presented by the Secretary, and after brief discussion, ordered printed.

Mr. Weston gave an interesting account of a mammoth electric light plant now under construction in the city of London. A general discussion in regard to the application of any motor to direct propulsion on street railroads then ensued. There was some doubt of securing adequate adhesion under all the conditions of track obtaining in crowded cities.

A committee was then appointed to present at the next regular meeting a programme for the annual meeting, and to report upon nominations of officers and rules for their election.

AT the regular meeting of December 5 the report of the Committee on Employment was laid upon the table, and the Chairman, Mr. Liljencrantz, wishes correspondence from members interested in the matter with a view of calling it up at a later date and disposing of it.

It was decided that the annual meeting should be held January 8, and that a lunch be provided. Nominations for officers, to be chosen by letter-ballot, were made.

Civil Engineers' Society of St. Paul.—At the meeting of November 5 the Secretary read a report on the standard form of Contract for Buildings as proposed by the National Association of Builders, and an informal communication from the Vice-President of the said Association recommending the members to use the form of Contract in any work they might let to which it was applicable.

Mr. J. D. Estabrook read a paper upon the Artesian-Wells of St. Paul and Vicinity and presented the Society with some blue

prints showing the location of the wells and a profile giving depth, elevation of ground surface, height of water in wells, and some information relating to the strata passed through. Beneath the drift formation are found layers of limestone and sandstone. The wells vary from 200 ft. to 1,600 ft. in depth, but few are flowing wells. The larger portion require the water to be pumped, and the deepest wells do not afford the largest supply of water.

The subject is of local interest at present, as the Board of Park Commissioners have under consideration the sinking of an Artesian-well to supply Como Park (200 acres) with water and to fill up Como Lake (50 acres) about 5 ft. to its former height, and to maintain it at that height by the water to be thus obtained.

AT the regular meeting of December 3 the paper of the evening was read by Mr. S. D. Mason upon the History of a High Viaduct built in 1883–84 by the Northern Pacific Railroad over Masent Gulch. The height of the viaduct at the centre is 216 ft. The timber was cut and sawed near the spot. The iron and supplies used were hauled by team for 80 miles. In 1885 the wooden structure was replaced by an iron viaduct from designs by George S. Morison, C. E. Mr. Mason's paper was illustrated by photographs of the wooden and of the iron structure and prints of the working drawings for the two structures.

New England Railroad Club.—The regular monthly meeting was held in Boston December 12. There was an interesting discussion on the Arrangement of Shops and Machinery for the Construction and Repair of Railroad Rolling Stock. The discussion was opened by Mr. J. W. Marden, and was continued by Messrs. Adams, Lauder, Griggs, Whitney, Coleman, and Professor Lanza, many statements of experience and practice being made.

New York Railroad Club.—At the meeting of November 15 Mr. James Howard read a paper on Train Brakes for Freight Cars, which was briefly discussed. Mr. R. W. Bayley read a paper upon the same subject, which was also discussed, and he was followed by Mr. Loughridge, who read a third paper on the same subject. This was followed by a general discussion of the whole subject of freight-train brakes.

AT the meeting of December 20 the subject for discussion was Car Wheels and Axles for 60,000-lbs. Freight Cars, the discussion being opened by Mr. J. R. Barr, of the Chicago, Milwaukee & St. Paul, who read a paper on this subject, also giving some notes of experience with the contracting chill process for making wheels.

Northwest Railway Club.—A meeting was held in St. Paul, Minn., December 1, at which a number of railroad men were present. W. T. Small was called to the chair, and H. P. Robinson appointed Secretary. After a brief discussion it was resolved to organize a society to be known as the Northwest Railway Club; to hold monthly meetings for the discussion of railroad questions, etc., in the same manner as the railroad clubs in Chicago, Boston and New York. Committees on constitution and on rooms were appointed, and were directed to report to an adjourned meeting, at which it was expected that a permanent organization would be formed. The Club is intended to include in its membership the very considerable number of railroad men who have their headquarters in St. Paul and Minneapolis.

Western Railway Club.—At the regular meeting in Chicago, December 18, the first subject for discussion was: Relative Merits of Thick and Thin Tires; and to what Extent are the Railroads Moving to Adopt the Master Mechanics' Standard Sizes of Tires and Wheel Centers.

The second subject was Water Circulation and Purification of Water for Boilers. This subject was opened by a paper written by Mr. Herbert Hackney, of the Atchison, Topeka & Santa Fé Railroad.

OBITUARY.

JOHN REMSEN ONDERDONK, who died in Chicago, November 22, aged 48 years, was born in New York, and was educated as an architect and civil engineer. He was for a long time employed on the Central Pacific Railroad, having superintended the grading of a large part of the main line of that road. He was also employed in designing and superintending some of the most important works about the harbor of San Francisco. For some time past he has had charge of the construction of the new water-works tunnel in Chicago.

J. F. COIGNET, the French engineer, whose death has just been announced, was well known by the association of his name with the *beton agglomere*, invented by him in 1855, and used in the foundations of the Vanne Bridge and the Port Said Lighthouse, and other important works. He was a member of La Société des Ingenieurs Civils, and prominently identified with industrial inventions for the last 40 years.

GENERAL JAMES C. LANE, who died in New York, December 12, aged 65 years, was for many years a civil engineer. Nearly 40 years ago he was employed in the surveys and construction of the Illinois Central Railroad, and was afterward for several years on the United States Coast Survey, and was then for some time engaged in mining surveys in Cuba and Porto Rico. He served in the Army during the war, and afterward was employed in mining surveys in California, Arizona, and Nevada. He was Chief Engineer of the South Side Railroad of Long Island. Recently he was employed in laying out the proposed new parks in the Annexed District of New York.

GENERAL THOMAS J. POWERS, who died in Rochester, Pa., December 1, aged 81 years, was one of the oldest civil engineers in this country. His first work was done as Assistant in the construction of the Erie Canal, and he was employed afterward on the Rome & Oswego and other railroads in New York; on the old Portage Railroad over the Allegheny Mountains; on the Virginia Central (now the Chesapeake & Ohio), and on improvements on the Kanawha and Monongahela rivers. General Powers retired from active work several years ago.

COLONEL ROBERT R. BRIDGERS died suddenly in Columbia, S. C., December 10, aged 71 years. He was born in North Carolina and trained as a lawyer, and in 1865 was chosen President of the Wilmington & Weldon Railroad Company, holding that position until his death, and serving also for a number of years as Manager of the Atlantic Coast Line, of which his road was a part. It was mainly due to his ability as a manager that the Wilmington & Weldon Railroad recovered from the prostrate condition in which it was left after the war and became a solvent and prosperous company, and under his charge numerous branches and extensions were built. Colonel Bridgers acted for several years as President of the General Time Convention, and was active in other railroad associations.

DAVID A. STEWART, who died suddenly in Pittsburgh, December 14, aged 57 years, was born in Chambersburg, Pa., and at an early age removed to Pittsburgh, where his father was the first ticket agent for the Pennsylvania Railroad. When quite young he was appointed clerk in the Pennsylvania Railroad freight station at Pittsburgh, and afterward gave up that business to enter the Columbia Oil Company, with which he was connected for a number of years. He afterward became one of the owners of the Pittsburgh Locomotive & Car Works, and has been for a long time President of that corporation. In 1872 he engaged with his present partners in the construction of the Edgar Thomson Steel Works, and soon after entered the firm of Carnegie Brothers & Company. For several years past, besides the presidency of the Locomotive Works, he has held the office of Chairman of Carnegie Brothers & Company, Managing Director of Carnegie, Phipps & Company, and President of the Carnegie Natural Gas Company. As may be supposed, he was a very active and busy man, and his time was fully employed. His death was entirely unexpected, although he had not been in full health recently and was making arrangements to take a trip to California for that reason. Mr. Stewart was a cousin of the late Thomas A. Scott, and was intimately connected with him in business. He leaves a large fortune to his wife and three children, who survive him.

WILLIAM R. DAVENPORT died very suddenly in Erie, Pa., December 13, aged 57 years. He was born at Watkins' Glen, N. Y., but when still a child removed with his parents to Erie, where he passed the remainder of his life. At the age of 15 he began business life as a clerk in a store in that town, and some years later was clerk and afterward station agent of the Cleveland, Painesville & Ashtabula Railroad. In 1866, with Mr. John Fairbairn and Mr. William A. Galbraith, he commenced the manufacture of car wheels, and two years later added car works on a small scale. From these small beginnings gradually grew the extensive establishments known as the Erie Car Works

and the Car-Wheel Works of Davenport, Fairbairn & Company, and their success was largely due to Mr. Davenport's energy and ability. In 1881 the business of the firm was so far extended that they decided to manufacture their own car-wheel iron, and built the Martel Furnace at St. Ignace, Mich. Mr. Davenport acquired considerable property, and leaves a valuable estate. He was interested in several other companies as a stockholder. He was prominent in church and benevolent matters, and was always a liberal giver for such objects. He leaves a widow, one son, and three daughters. His son, Mr. Charles W. Davenport, has been associated with him in business for several years. He was highly respected by his friends and neighbors, and, indeed, by all with whom he came in contact, for his uprightness, ability, and public spirit.

LUCIEN GAULARD, who died in Paris, France, November 26, was born in 1850, and was well known in French and English scientific circles. His name is associated principally with the system of electrical distribution by secondary generators, which occupied his sole attention during the last six or seven years; his earlier efforts were devoted to various branches of electrical and chemical science. In 1881 M. Gaulard showed at the Electrical Exhibition in Paris his thermo-electric battery, which excited a great deal of attention. It was at this time that M. Gaulard was invited by Mr. Gibbs to come to London, and since then, up to the time of M. Gaulard's illness in the spring of the present year, he was a director of the National Company for the Distribution of Electricity by Secondary Generators (Limited). M. Gaulard was a member of the Society of Telegraph Engineers, and was decorated by the King of Italy at the Turin Exhibition in 1884. He leaves a widow but no family.

The London *Electrician* says: "The history of invention scarcely contains a more mournful story than that of M. Gaulard. To him, beyond all question, belongs the honor of having initiated one of the most brilliant and successful developments of electrical engineering. . . . By a most unhappy fate, M. Gaulard contrived just to miss the one point of detail in the method of using his apparatus which involved the difference between commercial success and practical failure. Having thus missed his way, he had, in consequence, to suffer the mortification of standing idly by while other men were eagerly pursuing the track upon which he first set out. But though it is impossible not to feel the deepest sympathy for the unfortunate position in which M. Gaulard was placed, we believe it to be equally impossible to cast the blame of his misfortunes upon other shoulders. In actual life every man must abide the fortune of war with such fortitude as his individual temperament may permit. Unhappily, in this case, the strain proved at length to be greater than the mental equilibrium of the inventor could sustain. And notwithstanding the gleam of sunshine which the purchase of the American patent by the Westinghouse Company must have brought, yet in the early part of last summer his intellect became clouded, and it was found necessary to place him under restraint."

PERSONALS.

CAMPBELL WALLACE has been reappointed Railroad Commissioner of Georgia for a second term of six years.

JOHN MCLEOD, Chief Engineer of the Louisville Southern Railroad, has been appointed General Manager of that road.

R. L. VAN SANT is now Chief Engineer of the Indianapolis, Decatur & Springfield Railroad.

W. B. HANLON has been appointed Chief Engineer of the Cleveland, Lorain & Wheeling Railroad.

S. R. PATTERSON is Chief Engineer of the Kansas City, Fort Smith & Southern Railroad.

O. F. BALSTON has been appointed Chief Engineer of the Kings County Elevated Railroad in place of ANDREW BRYSON, resigned.

F. I. CABLE has been appointed Assistant Engineer of the Chesapeake & Ohio Railroad, with special charge of new bridge construction.

JOHN S. WILSON, late General Traffic Agent of the Pennsylvania Railroad, has been chosen President of the Poughkeepsie Bridge Company.

R. M. RICHARDSON has resigned his position as Master Mechanic of the St. Louis, Iron Mountain & Southern Railroad, after 22 years' service on the road.

GENERAL JOHN NEWTON has resigned the position of Commissioner of Public Works of New York City, to devote his time to his private business interests.

J. T. HARAHAN has resigned his office as General Manager of the Louisville & Nashville Railroad, to accept the position of Assistant General Manager of the Lake Shore & Michigan Southern.

CHARLES P. COLEMAN has been appointed Chemist of the Lehigh Valley Railroad, with office at South Bethlehem, Pa. He will have entire charge of the supply of oils, tallow, and similar articles, in addition to other duties.

SAMUEL SPENCER retires from the position of President of the Baltimore & Ohio Railroad Company after a term of very active service. He is succeeded by CHARLES F. MAYER, of Baltimore, for some time past President of the Consolidation Coal Company. Mr. Spencer's retirement is due entirely to changes in stock interests.

NOTES AND NEWS.

The Williamson Technical School.—A technical school on an extensive scale for instructing boys in various trades is to be established under a donation made by Isaiah V. Williamson, of Philadelphia. The fund given by Mr. Williamson consists of securities amounting to $1,536,000, and under the deed of trust these securities are to be appraised and then divided as nearly as possible into two parts. One-fifth is to be composed of securities which are easily and advantageously salable, and will constitute the building fund. The remaining four-fifths will go to the endowment fund.

The object which Mr. Williamson has in view is to train young men to mechanical trades, so that they may earn their own living, and every student who enters the school will be compelled to learn thoroughly one good mechanical trade. Their general and moral instruction is also provided for.

A New Petroleum Yacht Engine.—The recent launching of John A. Secor's yacht *Eureka*, in Brooklyn, N. Y., which is to be propelled by his system of atomized petroleum exploded by electricity, was a subject of much interest to scientists and engineers.

The motive power is applied directly to the water through pipes at the bow and stern, and is the expansive or elastic properties of oil gas, which is injected into the cylinder in the form of spray, and is suddenly converted into gas by electricity. The cylinder is 10 ft. long and 20 in. in diameter, and is placed just below and parallel with the surface of the water. The oil-tank is surrounded with a jacket of water, and is so constructed that only the malicious boring of a hole in it could bring about the possibility of an explosion. The cylinder is constructed to stand a strain 50 times as great as is produced by the heaviest possible explosion of the atomized petroleum. The machine is automatic except for the small amount of electricity needed to explode the gas. The forward pipe, which is provided, is to be used for backing and stopping the vessel.

The Burning of the "Maryland."—The transfer steamer *Maryland*, which was used for conveying passengers from the Pennsylvania Railroad station at Jersey City to the New Haven freight station at the Harlem River, was burned on the evening of December 7 just as she reached her dock. The boat was a total loss, and the four cars on board, belonging to the Boston Express, which leaves Washington at 2.30 P.M., were burned down to the running gear.

The *Maryland* was built in 1852 for the ferry across the Susquehanna from Perryville to Havre de Grace, on the Philadelphia, Wilmington & Baltimore Railroad, and was the first steamer used for transferring trains on tracks laid upon the deck. During the war she was used on Chesapeake Bay for transporting troops by General Butler, but resumed her place until the bridge at Havre de Grace was built; from that time to 1875 she was laid up, but soon afterward was purchased by President C. P. Clark, of the New York & New England Railroad, and rebuilt in her present form. She was then brought to New York, arriving there May 1, 1876, commenced to transfer first passenger trains then first run through between Washington and Boston, and she was the originator of the link in railroad connection between the Pennsylvania, the New York, New Haven & Hartford, and the New York & New England roads. The *Maryland* was a notable boat in her time, and was an object of much curiosity and interest when she first began her trips across the Susquehanna.

New English Steamers.—In the yard of Caird & Company at Greenock, Scotland, there has just been completed a new steamer called the *Peninsular*, for the Peninsular & Oriental Steamship Company, and the *Oriental*, a sister vessel, is nearly ready for launching. These ships are 410 ft. long, 48 ft. beam,

and 36 ft. deep, their gross tonnage being 5,500 tons; the loaded draught is 25 ft., the displacement 9,000 tons, and the dead-weight carrying capacity about 4,000 tons. They are built of Siemens steel, with four steel decks, the upper deck being strengthened for gun platforms, in accordance with Naval Reserve requirements. They are divided by eight water-tight bulkheads, all extending to the spar deck.

These ships will carry 180 first-class and 32 second-class passengers. Very handsome saloons, staterooms, and other accommodations are provided. They will be lighted throughout by electric lights, and will each be provided with two search-lights, for use in passing through the Suez Canal.

The motive power consists of a triple-expansion engine, the cylinders being 38 in., 59½ in., and 96 in. diameter, with stroke of 66 in. Steam is supplied from three double-ended and two single-ended boilers, having in all 24 furnaces, and the working pressure carried will be 150 lbs. It is expected that the sea speed will be about 16 knots an hour. They are provided with steam steering gear and with special machinery for ventilation.

The St. Clair River Tunnel.—Work has been begun on this tunnel, which is to extend under the St. Clair River from Sarnia, Ontario, to Port Huron, Mich. There will be no intermediate shafts; the tunnel will be worked entirely from two portals. Its total length will be 4,620 ft., about 2,400 ft. being under the river, which has there an extreme depth of 42 ft. The roof of the tunnel will be about 25 ft. below the river-bed; the material through which it is to be driven is a tenacious blue clay. The tunnel will have a circular section of 20 ft. 4 in. outside and 19 ft. 10 in. inside, and will be lined with cast-iron segments, which are made 18 in. wide and 2 in. thick, and are provided with 6-in. flanges, by which they are bolted together. Fourteen segments, with a key piece 10 by 18 in., complete a circle. The tunnel will be driven through the clay by hydraulic pressure, a cast-steel shield 5 ft. by 21 ft. and 4 in. thick being forced forward into the clay by 24 hydraulic jacks, which together exercise a pressure of about 3,000 tons. Air will be supplied to the tunnel by two 30 H.-P. blowers, and it will be lighted, while the work is going on, with electric lights. The cost of the tunnel, it is expected, will be over $2,000,000.

A California Dam.—The Folsom Dam, which is now being constructed across the American River above the California State Prison, for the purpose of furnishing motive power to the prison and innumerable manufacturing industries, is a work of some importance.

The concrete foundation beneath the solid masonry has an average depth of 4 ft., but on the lower side of the dam it is much greater by reason of the downward pitch of the bedrock. The width of base of the structure on the bedrock is 61 ft., and will be 25 ft. on top when completed. The height of the structure at the present time is 20 ft. 6 in., and when completed will be 69 ft. The entire length of the dam will be 469 ft. Of this 218 ft. is the tangent, or portion extending directly across the river; 121 ft. of curve, by which the water will be turned to the State Prison side of the river, and 130 ft. of wing for conducting the water to the canal. It is estimated that about one-sixth of the masonry work of the entire structure is now completed, but considering the great difficulty in controlling the flow of the river, and in getting the foundation laid, much more than that proportion of the work is done.

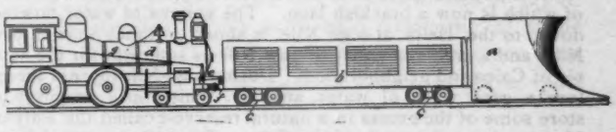
The temporary dam for turning the water from the bed of the river through a flume was completed in September, but the laying of stone was practically commenced on October 1. From that date to November 15 about 90,000 cubic feet of granite was laid.

New French Steamships.—A steamer named the *Paraguay* has been launched at St. Nazaire for the Compagnie des Chargeurs Réunis. The *Paraguay* is 379 ft. long, and has a carrying capacity of 2,200 tons. She will be fitted with engines working up to 1,900 H.P., and she is expected to attain a speed of 13 knots per hour. She will have accommodation for 60 first-class passengers, 40 second-class passengers, and 600 third-class passengers. The steamer *Battambarg*, built for the Compagnie Messageries Fluviales de Cochin-Chine, has just been launched at Nantes. The *Battambarg* is 197½ ft. long, and has a carrying capacity of 400 tons. She is fitted with engines working up to 680 H.P., and she attained on her trial trip a speed of 12 knots per hour. The *Guadiana*, a vessel of 2,570 tons, built for the Messageries Maritimes, has been launched at Havre. The *Guadiana* is 351 ft. long, her engines work up to 1,500 H.P., and she is expected to attain a speed of 13 knots per hour. She will carry 36 cabin passengers. A small steamer, 113½ ft. long, and named the *Wangpoo*, has been launched at Shanghai; she was built for the Messageries Maritimes, and will be employed by that company on the Yang-Tsé. The *Eugène Pereire*, just completed at St. Nazaire, has left that port for Marseilles, and will run between Marseilles and Algiers; she is 356 ft. long by 35¾ ft. beam, and 29 ft. deep. She is fitted with triple-expansion engines working up to 2,000 H.P., and she attained a speed of 17 knots per hour upon her trial trip. She will carry 200 first-class and 50 third-class passengers, and she is expected to prove herself the swiftest steamer engaged in the Mediterranean trade.

Cornell University.—The recently issued catalogue says: "The Mechanical Laboratory, which is the department of demonstration and experimental research of Sibley College, and in which not only instruction but investigation is conducted, is located in the annex of Sibley College, in several rooms of good height, well lighted on all sides, and carefully fitted up for the purpose for which they are designed. It occupies the whole lower floor, a space 150 ft. long by 40 ft. wide, and represents the latest contributions of Mr. Sibley to the University. It is supplied with the apparatus of experimental work in the determination of the power and efficiency of the several motors, including steam engines, and the turbine driving the machinery of the establishment; with boiler-testing plant and instruments, and with a number of machines for testing lubricants and the strength of metals. Among these is the autographic testing machine, which produces an autographic record of the results of the test of any metal which may be placed within its jaws, securing exact measures of the strength, the ductility, the elasticity, the resilience or shock-resisting power, the elastic limit, etc., of the material. Several steam-engines and boilers, air and gas-engines, several kinds of dynamometers, lubricant-testing machines, standard pressure-gauges, and other apparatus and instruments of precision employed by the engineer in such researches as he is called upon, in the course of his professional work, to make, are all collected here."

A Snow-Plow Battering Ram.—An inventor, who has apparently been studying the ancient battering ram, has recently taken out a patent for "improvements in the art of forcing snow-plows through snow-drifts," his invention consisting of the use of a weighted car, or battering ram on wheels, by which the snow-plow is to be pounded into or through a bank. The accompanying engraving will show his method; in it *a* is the snow-plow, *b* a car body mounted on the trucks *c* and loaded as heavily as their strength will permit, and *d* the engine. There is added to the engine a bell-crank lever, *e*, one arm of which is connected with the coupling-pin and the other with the rod *g*, extending to the cab, so that the engine can be coupled to or uncoupled from the car *b* while in motion. The operation of his device is as follows:

"When the plow *a* becomes stuck in a drift or bank, so that the engine cannot crowd or push it therethrough, the engine will be coupled with the car or body *b*, and the latter, disconnected from the plow *a*, will be drawn back a suitable distance and run forward at great speed until it approaches near to the plow *a*, when the engine, if not previously disconnected from the body *b*, will be uncoupled therefrom and reversed. With this operation the body *b* will by its own momentum be carried forward with great force against the plow, driving it into or through the drift or bank, while the momentum of the engine will have been overcome, or so far overcome by the reversing of the same as to receive an inconsequential amount of the impact or shock. In case the plow should not be driven through the bank or drift the operation just described may be repeated until it is forced to a point where the engine or engines may be able to push it steadily ahead."



The inventor says that the form or construction of the plow or engine is not of importance. An impartial observer will probably coincide with this view, and will also be inclined to doubt whether the plow—possibly the engine also—will have much form of any kind after the device has been in operation for a short time.

The inventor of this arrangement is John Byfield, of Chelmsford, Mass., and his patent is No. 392,905.

A New Draftsman's Scale.—At a recent meeting of the Engineers' Club of Philadelphia, Mr. L. F. Rondinella exhibited a "Scale of Proportionate Inches," designed especially for the use of mechanical engineers and machine draftsmen. The civil engineer has his scale of feet or inches divided decimally; the architect his scale of *proportional feet* where the unit (¾ in., 1 in., 1½ in., etc.) represents one foot and is divided into 12 parts for inches. But the mechanical engineer, though working almost exclusively in inches in his designs, has been obliged heretofore to use the architect's scale, transforming each

size from *inches* to *feet and inches* before laying it down on his drawing, with considerable loss of time and liability to error; while the scale that is perhaps most used by machine draftsmen—half size—is entirely absent from the architect's scale as usually made.

The scale of proportional inches contains the scales that are most used in practice—full size, half size, quarter size, and eighth size—in *inches*. The divisions are arranged as in the architect's scale, two scales on each edge, the unit outside of the zero point being subdivided in the larger sizes to sixteenths, in the smaller sizes to eighths. The graduations are United States Standard, engine-divided, and the scale is furnished in bristol-board or boxwood.

The Chilian Railroad Contract.—The Chilian Government has made a contract with Newton B. Lord, representing the North & South American Construction Company, an American organization, to build about 600 miles of railroad during a term extending over about five years. The lines to be built, with the contract prices, are as follows:

1. Calera to La Ligua and Cabildo, 76 kilometers, $1,650,000.
2. Huasco to Vallenar, 48 kilometers, $425,000.
3. Ovalle to San Marcos, 60 kilometers, $800,000.
4. Los Vilos to Illapel and Salamanca, 128 kilometers, $1,260,000.
5. Constitucion to Talca, 85 kilometers, $1,425,000.

The above lines are all to be narrow gauge—1 meter. Those named below are to be of the Chilian standard gauge—1.68 meters, or 5 ft. 6 in.:

6. Santiago to Melipilla, 59 kilometers, $1,050,000.
7. Pelequen to Puemo, 28 kilometers, $550,000.
8. Palmilla to Alcones, 45 kilometers, $600,000.
9. Coihue to Mulcheno, 43 kilometers, $625,000.
10. Vittoria to Valdivia and Osomo, 403 kilometers, $9,325,000.

This is a total of 578 kilometers of standard and 397 of meter-gauge, making 975 kilometers (607 miles) in all. The roads are to be completely equipped. The bridges are to be of iron of the American system. The final locations are to be subject to Government revision, and the conditions of the contract are very strict.

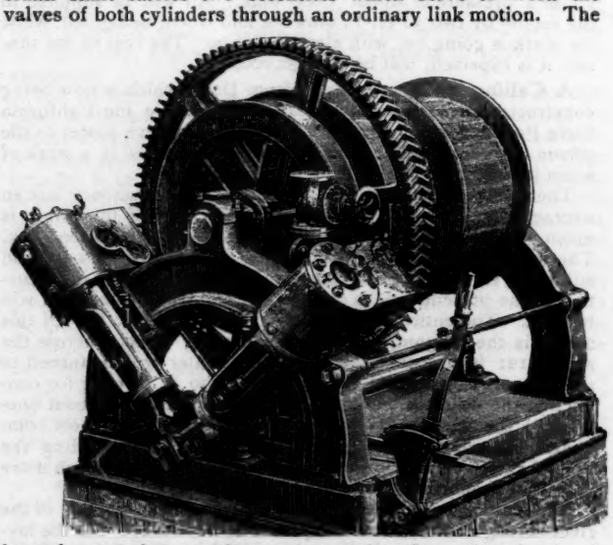
Project for the Storage of Nile Floods.—Owing to the extremely low Nile of this year the sanitary condition of Cairo is very unsatisfactory, and particular attention has been called to Mr. Cope Whitehouse's project for storing the flood-waters of the high Nile, in a natural depression of the ground southwest of the Fayoum District. At present the water is kept out from the district by the Mayana dam, formed of desert land, and dividing the Bahr Yusuf Canal from the Fayoum District, which embraces an area of about 1,000 square miles, a portion of which is now a brackish lake. The volume of water flowing down to the Delta at high Nile is about 40 times that of low Nile, and a treble quantity of low Nile is sufficient for the supply of Cairo and neighborhood. During high Nile there is therefore a great waste of water, and Mr. Whitehouse proposes to store some of the excess in a natural reservoir called the Raiyan Moeris, situated 75 miles from Cairo. By cutting a canal from the Nile through the dam above mentioned, and continuing it westward till this basin is reached, the latter could be filled at high Nile to 30 meters above sea level, and would then form a fresh water lake 250 square miles in area, and would contain over 20,000,000,000 tons of water. The actual storage required for the irrigation of the 2,500,000 acres of land, which could be reclaimed and made valuable in this way, is, however, only 2,500,000,000 tons. It would require one season to fill the small basins and three seasons to fill the whole reservoir. The total cost of the work is estimated at $1,750,000. The work would, in effect, form a reservoir in which the surplus of a wet year could be stored up and saved for use in a dry season.

The First Locomotive Cab.—Mr. E. E. Duncan, who is now a resident of Detroit, and who can claim to be one of the oldest locomotive engineers now living, writes that he began railroad work on the old New Jersey Railroad, April 1, 1836. For nearly two years afterward the road was operated between Jersey City and Newark by horse power. After serving an apprenticeship of three years in the shop he went on the road as a locomotive engineer, continuing in that position for somewhat over 25 years.

Mr. Duncan says that the first cab put on a locomotive to his knowledge was in 1838, when the then Master Mechanic of the New Jersey Railroad fitted one on the locomotive *Newark*, which was a Rogers engine, with a single pair of drivers. It was a primitive affair, consisting of a wooden front and a roof, with glass windows, 8 by 10 in. in size, in front to look through, and fitted at the side with leather curtains, which were rolled up like carriage curtains. This improvement attracted considerable attention, and Mr. Thomas Rogers came down from Paterson to look at it; he approved of the idea wholly, and a short time afterward he designed and put on a locomotive built in his shop the first permanent cab, and from that time on the cab was a regular part of the locomotive.

Mr. Duncan claims to have made very fast time during his service on the New Jersey Railroad. In 1852, he writes, when the telegraph was still new, he was asked by the Superintendent of the road if it would be possible to get the President's message through to New York by train in quicker time than it could be telegraphed by the slow methods of those days. The message was sent through by special engine, and Mr. Duncan ran his part of the trip, from New Brunswick to Jersey City, 31 miles, in 33 minutes. The engine with which this time was made was the old *Jersey City*, a Rogers engine having a single pair of 5-ft. drivers, an ordinary truck forward, and a single pair of bearing wheels behind the fire-box. This was the last Presidential message carried to New York by rail, as improvements in the telegraph made shortly afterward increased the speed of transmission so much that competition was hopeless.

A German Hoisting Engine.—The accompanying illustration, taken from *Glaser's Annalen*, shows a hoisting engine driven by compressed air, which has lately been put up by the Prince Rudolph Mining Company at Dulmen, Westphalia. The entire machine is mounted on a bed-plate cast in one piece, and is so arranged that it can easily be moved if necessary. On the bed-plate are bolted two arched standards which carry at the top the boxes in which the shaft of the hoisting drum revolves. On one of these standards the two cylinders are bolted, placed at right angles to each other and at an angle of 45° with the bed-plate. The guides are cast with the cylinder-head as shown, and are bored out, the cross-head having a circular form. Both connecting-rods work on a crank attached to a shaft which runs in two bearings bolted to the bed-plate. This shaft carries a pinion with spiral teeth which works in a large gear wheel fixed on the shaft carrying the hoisting drum. The crank shaft carries two eccentrics which serve to work the valves of both cylinders through an ordinary link motion. The



lever for stopping, starting, and reversing the engines is placed in front, as shown, on a bracket bolted to the bed-plate.

The hoisting drum is of cast iron lagged with oak. On the main shaft there is also a heavy wheel to which a brake can be applied through the foot lever shown in the engraving. The brake-shoe is of iron faced with oak. The two standards are braced and held together by two heavy bolts placed at the level of the lower end of the cylinders.

The cylinders are 170 mm. (6.7 in.) diameter and 160 mm. (6.3 in.) stroke. The driving pinion is in proportion to the large wheel as 1 : 6. The usual working pressure of compressed air is four atmospheres, and with this pressure the engine can lift 400 kilos. at the rate of 1 meter per minute. The hoisting drum is 800 mm. (31.5 in.) diameter. The whole machine takes a floor space of 3.5 square meters (37.7 square feet), and the total height from the bottom of the bed-plate is 1.950 meters (6 ft. 5 in.).

Several of these machines have been at work for some time with very good results. The advantages of compressed air over steam for working such an engine in mines or other places where the ventilation is poor and the heat great are too well known to need repetition. There is also a special advantage in the use of compressed air where steam would have to be carried a long distance through pipes, causing much loss by condensation.